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Bridge over the Theiss, and Tubular Foundations. By M. CEZANNE, Engineer des Ponts et Chaussées. Translated by J. BENNETT.

(Continued from page 90.)

PART THIRD—(*Continued.*)

Air Pumps.—The air pumps used at Szegedin were composed of two vertical cylinders a short distance apart. In the upper cylinder, which was 8·66 ins. diameter, the steam worked a piston having the same rod with the piston of the pump, which was 11·8 inches in diameter.

The stroke of the piston was 7·87 ins.; the number of strokes per minute was from 100 to 120.

These machines were double-acting, with a variable expansion and a free escapement. They were from 10 to 12 horse-powers and weighed 4840 pounds; the steam was furnished by old locomotives planted upon a pontoon, coupled with a similar pontoon, bearing the coal and watchman's box.

The apparatus thus being installed, the bell loaded with the counterpoise, designed to equilibrate the interior pressure, the column being inserted between its guides, and the inner doors of the air chamber being shut, with one valve at least open, the pumps were set at work.

At first there was much leakage through the air chambers, but the pressure increasing closed the doors or valves against their linings, and the joints became air-tight. At Szegedin, it required one hour's work of one pump to obtain one atmosphere of pressure. When the interior pressure was sufficient, the interior cock of the syphon was opened, and the water rose to its delivery. By a little contrivance the water could be exhausted at a less pressure than required by the usual hydrostatic laws; by slackening a joint in the lower part of the interior syphon, a little air was admitted, and the mixture of air and water being lighter than water, was raised before attaining the pressure required for pure water.

The diameter of the syphon was 2·36 ins.; the time required to draw off 705·7 cubic feet of water was, in good working condition, one hour.

When the water was exhausted, the men went in, and the work began. A gang was usually composed of nine men:

One overseer, sometimes inside, sometimes outside.

Two miners at the bottom of the column.

Four hands at the interior windlass (placed upon the platform), upon which was rolled a chain, with a full bucket ascending at one end, and an empty bucket descending at the other.

Two men upon the reservoir, to draw up the full buckets placed in the air chamber by the men within. This operation was performed by means of a common wood windlass placed upon the counterpoise.

There were besides these, a stoker and his assistant, and one to take charge of the manometer.

The valve being opened, the men and the buckets were passed into the air chamber. The men at the exterior windlass made fast the hook of their chain to the ring or handle of the valve, and raised it to press against the india-rubber lining.

The cocks being suitably worked by the person who enters or by the men outside, if a bucket is to be passed, the air blows in the chamber; the valve closes of itself, and the lower door opens.

Physiological Effects of the Compressed Air.—This is the proper place to give some details as to the physiological effects of the compressed air. It may be regarded in three phases—the entrance, the remaining, and the departure.

When cooped in the air chamber to allow the closing of the upper valve, a cock is opened for the entrance of the air, one is immediately seized with a violent buzzing in the ears, attended with pain, whose intensity varies with individuals. The air is of an oppressive heat, with a strong smell of caoutchouc and sweat. There is utter darkness. Care must be taken to avoid opening the cock for the entrance of the air, before making sure that the outlet orifice is well closed. If this precaution is neglected, one is caught in a violent current of air, which immediately causes severe neuralgic pains in the teeth, temples, and ears.

When no regard is paid to favoring the ears, and the cock is opened briskly, as is usually done by the workmen, the pressure is established

in less than a minute, and the lower door opens. On reaching the platform at the side of the windlass hands, the air is very damp and heated by compression; this space resembles a drying room, and at Szegedin the thermometer rose above 140°.

To reach the miners, one is lowered in a bucket; and in proportion to the descent, the air becomes more fresh and pure. At the bottom of the column, when the water is completely cleared, and the bottom dry, the position is supportable; still the excessive comfort spoken of by an author* is not experienced, but a sensation of relief similar to that succeeding a painful operation.

The passage through the air chamber is quite disagreeable; some persons, however, are so accustomed to it as to think nothing of it; but there are workmen who, after many weeks perseverance, become discouraged, and decline the high pay tendered as a bonus for their sufferings.

The position at the bottom of the tube, under a pressure of 3 atmospheres, may be prolonged many hours without inconvenience; the tone of the voice is somewhat changed, the respiration increased as by a rapid walk; a dry cigar kept in motion is consumed in a flame; the wax-lights burn rapidly, but with a smoky flame, depositing lampblack on all sides; it quickly blackens the nostrils, the bottom of the throat, and penetrates the lungs; smut is blown from the nose, and spit from the mouth, for many days after a long stay in the tubes. These discomforts are more apparent with oil lamps.

The time of departure, though but little painful for the majority of individuals, is the most dangerous for the workmen. As soon as the compressed air escapes from the air chamber, the temperature lowers suddenly, the vapor condenses, and when the upper valve is opened, one issues surrounded by a cloud. At this moment blood sometimes flows from the nose and the throat; some persons experience violent neuralgias, but of short duration; others have tooth and headache for many days.

Most frequently the leaving is attended with no other sensation but that of a cold air douche, followed by a slight tension of the ears.

The men who usually work in the tubes look ill; but they persevere steadily, and up to pressures of 3 atmospheres we may be sure of finding as many workmen as are required for the working of the tubes.

There were at Szegedin some miners who had worked at the Quarantaine bridge at Lyons, and at the bridge at Macon, whose health was perfect. One died of paralysis of the lungs, but his habits were very irregular.

The fever, endemic along the borders of the Theiss, has not attacked the miners more than other workmen; in a sanatory view it seemed that they might be rather classed by nationality; the Italians and the Germans were the most sickly, the French and Hungarians were in better health.

A gang of nine men worked six hours and rested six hours; the work progressed night and day.

* Revue des Deux-Mondes, 1st Nov., 1857, p. 207.

Fifteen buckets of clay or sand were taken out per hour; the contents of a bucket being 2·47 cubic feet.

The slowest operation was the raising of the buckets, and some interest was felt in expediting the work; at the bridge of Bordeaux, this was effected by making an opening in the cylindrical sides, midway of the column, to which was fitted a special air chamber, through which the excavation was emptied.

At Szegedin, the ends of the chain bearing the buckets, on leaving the windlass, passed over a gibbet, M, fixed upon the plane part of the air chamber, and movable around a vertical axis. By this arrangement the bucket is raised to the level of the air chamber, in which it is deposited without effort if the vertical door is open.

Then this door is pushed to, the cock is turned, the door closes, the upper valve falls, and the men outside fasten their end of the chain in the handle of the bucket, raise it, and replace it by an empty bucket, which by a turn of the cock is put at the disposal of the men inside.

Sinking of the Columns.—When the excavation has reached the end of the tube, the miners leave, after taking up the lower branch of the syphon, and placing their tools upon the interior flooring; the column is adjusted in its guides, and the escape valves are opened briskly.

The effect then produced varies with the nature of the bottom, and in the same bottom with the plugging of the tube, the height of the water, and the load of the column, &c.

At the first trial of the sinkage of a column on the Theiss (the first pier) it lowered rapidly, carrying with it the guides, and there were fears of its swamping. It stopped after a descent of fourteen feet. Usually the descent varied from 3 ft. to 6·6 ft.; often, whatever the load upon the column, it remained insensible to the discharge of the air, and then started without apparent cause.

The interior pressure of the air equilibrates at the same time the outward pressure of the water and of the air, and the weight of the column, which would itself be lifted up were it not amply loaded. The moment the air escapes, the water enters violently at the bottom, bearing the earth with it, and the tube falls in proportion to the undermining thus made at its foot. The motion stops when the mass of water and sand let inside equilibrates the outward pressure, and when the friction of the tube is in equilibrium with its weight. The friction is very slight in sand and fine gravel, but enormous in clay. Now, as the latter is more difficult to undermine than the sand, we see that the effects of discharging the air must vary with the proportion of clay or sand in the bottom. When a column which has only gained a few inches under the action of many discharges of air, falls suddenly 1 or 2 yards, it is from the fact that having passed with difficulty through a clay bed, it then meets with a bed of sand more easily disturbed.

A column weighing 120 tons, having a depth of 19·7 feet, in a clay bottom, is stopped in the descent when there is a difference of 32·8 ft. between the levels of the internal and external water, and with only a slight interior tamping; while in the sand, a column weighing 40 tons, having a depth of 32·8 feet, and a tamping of 16·4 feet, falls of itself

if the rising of the water produces only a difference of 6·5 feet in the level.

In clay, the column adjoining that worked upon generally remains immovable during the ascent of the latter; in sand, it either settles or inclines. In clay, the columns have a slight tendency to deviate; in sand, they generally incline up stream, because on that side the river makes the first undermining.

From the above remarks it is seen how little control is had in arresting the columns at a desired plane, or in preserving a vertical direction. Each bottom has its inconveniences and its resources, and it becomes necessary to feel the way along by trial. The columns deviate most frequently in sand, but the deviations are most difficult to be righted in clay. The best bottoms are the gravel.

Means of Correction.—To right an inclined column, strong oblique shores abutting on scaffolds are applied to it. The head of the shores descends with the column, and drives it back on approaching the horizontal; the column inclining one side, it is pressed over the other side, and at each trial is made to approach the vertical.

When a column descends with an inclined direction, its foot moves horizontally; on this account some allowance must be made, either by increasing the counter-weight upon the side to be sunk, or in digging away the bottom more deeply on that side, so as to facilitate the undermining, and sometimes by placing strong oak wedges under the foot of the columns, and supporting them against a core of earth placed inside. The foot of the tube slides upon these wedges during the descent; but when the hold is considerable in the clay, it is difficult by these means to gain more than 1½ to 2 inches. When the errors are very great, there is no remedy but to withdraw the column, which can be effected by the windlasses, after establishing an equilibrium with the internal pressure.

As the plane of the foundation is approached the discharge of the air is moderated, by leaving a tamping at the bottom of the tubes, by controlling the escape of the air, and by unloading the column; if the motion is more rapid than desirable, the pressure may be renewed, and the tube stopped by a forced working of the pumps. At Szegedin, water pumps were placed near the air chambers, and sometimes the column was filled to the outer level, lowering the pressure proportionally, the only way of assuring the immobility of the tube. It is remarkable that a bottom in which the tube sinks spontaneously, with the least difference between the inner and outer levels, presents so great resistance to compression when a hydrostatic equilibrium is established.

Columns of 100 tons weight have often been observed to be supported upon the foundation by a surface of 1·863 square yards, formed of the end and flanch of the tube. This would be 91 pounds per square inch.

Whatever precautions are taken for directing the columns, it is well to count upon deviations of 4 inches in every direction, and to reserve the means of correcting them. This is quite easy when the columns

support uprights only. The errors, measured in the plane of the head, are as a mean 4 inches in each direction, giving a slope of 0·005 with the vertical; they may reach the double of these figures, and depend upon many circumstances, but chiefly upon the nature of the bottom, and the stiffness of the scaffolding which guides the column.

The increased volume of earth due to the descent is quite variable; as a mean at the Theiss it was threefold; in other words, the cube of the excavated earth, measured by the number and capacity of the buckets, was three times greater than the total void dug out by the miners. In clay the increase is hardly appreciable.

In the common applications of tubular foundations, as soon as by reason of the last discharge of air the column has reached the desired depth, the pressure is renewed, the miners take away the pugging, leaving however a thickness of earth of three feet, to check the variations of water level which follow the variations of the manometer; the necessary materials of sand and water are passed to them through the air chamber, and a layer of cement from 2 to 3 ft. thick is commenced. Care is taken to leave in the middle of this layer a cylindrical hole from 8 to 12 inches diameter, which is only filled at the moment when they begin to lay on the beton. This hole allows the water to enter the pumps, in case of accident, without destroying the body of the cement.

At Szegedin, when a column was at its depth it was filled with water an appointed height, to avoid the spontaneous sinkage, and the pneumatic fixtures being taken away, special diving bells were then used.

It was only after the driving of the piles to the desired refusal, that the first available pneumatic apparatus was put up for syphoning the water, to cut away the piles in pieces of 3 ft. for their passage through the air chamber, and to finish the excavation.

Betonage of the Columns.—When a column is ready for the beton, some buckets of beton are lowered, which is laid with the trowel at the bottom of the column to form a cushion, and then all the miners retire upon the platform under the reservoir. A barrow-gang is organized to fill the air chamber with beton; as soon as it is full, notice is given for those inside to clear the way; the upper valve is closed and the lower door opened by manœuvring the cocks as usual; the beton then falls upon the platform and at the bottom of the column. The miners inside clear the chamber with scrapers, and close the lower door; the upper valve falls, and the chamber is again filled with beton.

Whenever an approach is made to the flanch, the miners level the beton and fill up its recesses.

When the height of the beton is half that of the exterior water, measured from the plane of the foundation, the pressure is stopped, the receiver raised, and the beton laid in open air; after this the beton is crowned with masonry and the superstructure is raised.

The following table gives the principal dates of work of the second pier of the Theiss bridge:

Character of Work.	Dates for the	
	Up-stream Column.	Down-stream Column.
Sinking of the column, .	July 31, 1857.	August 4, 1857.
Pneumatic work—Commencement,	August 10, "	August 17, "
" " End,	August 31, "	September 6, "
Interior piling—Commencement,	October 25, "	October 9, "
" " End,	January 25, 1858.	January 8, 1858.
Betonage—Commencement,	March 10, "	March 6, "
" End,	March 13, "	March 8, "
Setting up the square bodies,	March 17, "	March 17, "

If the interior piling had not been required, the beton could have been introduced—

In the down-stream column, August 31, 1857.

In the up-stream column, September 6, 1857.

This operation for both columns would have been completed on the 15th of September; the entire pier would have been laid and prepared for the superstructure of the bridge in less than two months, with the use of but a single pneumatic apparatus. The interior piling and the severity of the winter of 1857–58, retarded the completion of the bridge several months, and yet the work was finished in two years after the settlement of the contract. This result could not have been attained with other systems of foundation, and the advantage of rapid execution has recommended the future use of tubular piers to all engineers.

The processes and apparatus above described have been applied to numerous works, and though convenient and sure, are yet susceptible of improvements. Many ingenious thoughts have become subjects for experiment or study upon some of the great European rivers, the Garonne, the Rhone, the Po, the Danube, the Vistula, &c. It is to be hoped that the authors of these works will make known the results.

We close this notice with some data relative to the net cost of the foundations of the Theiss bridge.

Net Cost of Tubular Foundations.—The cost depends upon the number of columns, their dimensions, the price of materials, &c. We shall consider only the expense of the pneumatic construction, in which we must distinguish the cost of the first establishment and that of manœuvring the apparatus.

An outfit for the Theiss bridge is comprised of the following parts:

A pneumatic reservoir, with its accessories, such as pipes, india-rubber linings, weighing 7000 kil., at 2 fr., ...	$2632·00
An air pump, weighing 1200 kil., at 4 frs., ...	902·40
Rough cast iron counter-weights, bought in England, 40,000 kil., at 10 centimes, ...	752·00
Besides these articles, representing about	$3534·40
The company furnished some old locomotives, answering for steam boilers, and some pontoons. For this part of the instalment we should reckon, as for special apparatus, ...	2105·60
The whole cost of the first establishment, amounting to . .	$5640·00

should be divided by the number of feet of the pneumatic piers, designed to be constructed with one outfit, either for one or many bridges.

This total does not include the planing or piercing machines, the loading cars, windlasses, tackle, &c.

The manœuvring of the apparatus is composed of the requisite loading for the instalment, and of the manœuvring proper.

The moving of the outfits from one pier to another cost as a mean at Szegedin, $56·40.

A similar moving from one column to another of the same pier cost $32·90.

An hour's working of the apparatus cost $1·99 distributed as follows:

	Frs.		Cts.
Workmanship—8 miners, at	0·35	=	52·64
1 miner, at	0·50	=	9·40
1 assistant fireman, at	0·25	=	4·70
1 watchman, at	0·25	=	4·70
Total of workmanship,	4·10	=	77·08
General expenses, one-third of workmanship,	1·37	=	25·75
Bonus for excavators,	0·40	=	7·52
Fuel and different furnishings,	4·75	=	89·30
Total,	10·	=	$1·99

The total pneumatic construction of 318 feet, divided between six piers, and so twelve columns of the Theiss bridge required

10 loadings, at 300 frs.,	$ 564·00
21 movings, at 175 frs.,	690·90
3451 hours, at 10·60 frs.,	6877·04
Total,	$8131·94
Or the mean cost per running foot of pneumatic construction,	$25·57

This price does not include the furnishing, the transportation, and maintenance of the apparatus, the jointing, the sinking of the columns, the carpenter's work in directing or repairing.

The introduction of 31,855 cubic feet of beton through the pneumatic bell, required 253 hours at $1·99, which may be regarded as the mean cost of the betonage under the bell, including leveling and interior damages, but exclusive of the carriage of the beton from its place of manufacture to the air chamber into which it was dumped directly from the barrow; this may be set at 56 cents.

The above cost of the moving of apparatus and of the running foot of pneumatic construction may be considered as proportional, all else being equal, to the cube of the diameter of the columns, and the depth required below the water.

NOTES.

NOTE A.—*Upon some effects of the variations of temperature observed at the Theiss Bridge.*

In preparing the plan, it was admitted, that the variations of temperature would, as is usual for arch bridges, have no other effect but to raise or lower the summit of the arches, that the distance between the piers would remain constant, that the efforts

produced by the changes of form arising from changes of temperature would attain their maximum in the upper chord, during the low temperatures, and that there was no occasion for solicitude, as might be inferred from a very simple calculation. The fastening of the upper chord upon the square bodies, being one of the conditions of the stability of the piers, it was proposed to complete it by mooring the ends of these upper chords behind the abutments.

In reality the rolled iron trusses are so rigid in the vertical plane, that they manifest a tendency to remain similar to themselves through the changes of temperature. In the early part of November, 1858, the north wind having suddenly reduced the temperature 18° Fahr. the whole bridge was seen to contract and the extremities tended towards the middle; the abutments partook partially of this motion; a slight crack between the mass of the right abutment and the viaduct, opened in the morning and closed at noon. On suppressing the mooring, the motion continued; the iron trusses were bound to the masonry solely by eight bolts of 1·97 inches secured with lead, into the stone, and resting the heels of the arches against their shoes with a screw fastening. These screws being suppressed, the abutments were immovable; but the heels of the arches separated from their shoes nearly ·39 inch. The summit of the arch then fell to its original level and resumed the form in which it had been constructed.

From this observation we conclude that the arches of the Theiss bridge exerted no thrust when unloaded, and that they could be held by simply being placed upon two supports at the springing line.

Six iron wedges in couples were driven between the heels of the arches and the shoes. In the morning the slant of the arches bore mainly upon the lower wedges, and at noon upon the upper wedges; advantage of this was taken in striking upon the upper wedges in the morning, and at noon upon the lower, so that the severest cold could not separate the heel of the arches.

In reality the arches act partly as a rigid girder, and partly as flexible arches. We observed, for example, that for a fall of 58·5°, the fourth pier remained immovable, the first advancing towards it 0·55 inches. Now, this pier is 437·8 feet from the fourth, and should approach it by 2·08 inches, if there were no change in the arches; the motion observed at the springing was 0·55 inches, proving in this case that the effect of change in temperature was divided between the piers, which received ·26, and the arches, which received the remainder.

Note B.—*Machine for making Beton.*

The beton for the Theiss bridge, was prepared in a machine widely known in Germany, but little known in France.

This simple machine is composed of a cylinder 13 feet long, and 4 feet diameter, open at its ends, and turning upon an axis inclined to the horizon. The stone and the mortar were thrown from a barrow into a hopper, which delivered them into the cylinder at its upper end. The mixture was effected by the rotation of the cylinder, whose lower end delivered the beton either into barrows or cars.

The interior of the cylinder was smooth and lined with sheet iron; the proportion of the materials was made by regulating the number of barrows of mortar and those of stone cast into the hopper. At Szegedin the cylinder was inclined to the horizon one-13th; it made from fifteen to twenty turns per minute, and the mixture was perfect. The cylinder was driven by a belt passing directly over its outer surface. Motion was given by an engine which worked at the same time a strong mortar mill.

This machine easily made from 104 to 131 cubic yards in ten hours, and so long as the loading of the materials was not included in the net cost, the expense per cubic

yard, is very small, and is but a fraction of the expense of the engines which drive the beton cylinders.

Note C.—*Pile Driving.*

At Szegedin there were three kinds of piling :—

1. The piles for the scaffolding, the service bridge, &c., were driven in the river; for the most part they were driven by steam; and the work progressed night and day. The machine gave sixty to eighty blows in one hour, the fall varying between 10 and 19½ feet.

2. The piles were driven upon the shore, for the foundation of the abutments; the pile drivers were worked by steam, with a ram 2200 pounds weight falling from 26 to 29½ feet. The heads of the piles were crushed in spite of their bands, but the parts towards the end of the driving, which jutted a little above the bottom, resisted well. The piles were of spruce. The engine worked a pump at the same time that it imparted motion to a horizontal shaft placed in front of the excavation. One or two pulleys worked the pile driver by means of a belt. A row of piles perpendicular to the horizontal shaft was driven without displacing the pulley.

3. The interior piles of the columns were driven by hand; the work went on night and day; sometimes forty hours were given to one pile, as the falls used were moderate. The ram, 880 pounds, was worked by a hand-rope of the pile driver. After 810 volleys a pile has opposed an absolute refusal during 180 volleys of 25 blows. The ram of 2200 pounds was taken; and the pile sunk 0·63 inch per blow with a fall of 9·3 feet.

These piles were cut to a diameter of 11·8 inches, so as not to tighten indefinitely the tamping of earth left in the columns; it was proved by direct experiments, that this packing consumed but a small fraction of the resistance of the pile, about one-15th, or in other words, that fourteen-15ths of the resistance of the pile was due to its fixture below the column, the only use for which it was designed.

The piles of the abutments and those of the first piers, were provided with iron shoes; but in excavating after the piling of the first pier, several detached shoes were found in the foundation, and they were abandoned in the last piers, the work being done better without them.

This experience confirms that of the Prussian engineers in the construction of the bridges of Dirschau, and of Marlenbourg upon the Vistula, in which they concluded that the shoe had no influence upon the driving of the piles. The same engineers charged with the construction of the bridge at Cologne, drove their piles unshod through the gravelly bottom. The system appeared however to be too absolute.

Deflection of Suspension Bridges. By Homersham Cox, M. A.

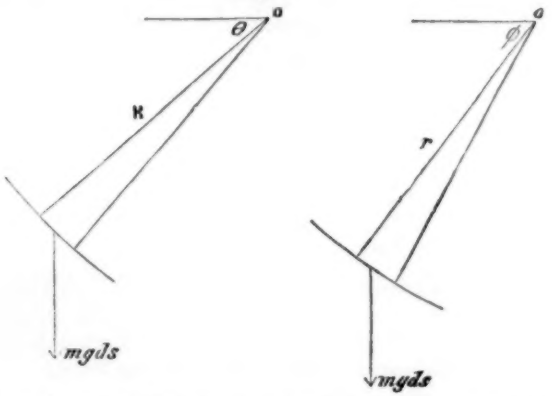
From the Civ. Eng. and Arch. Jour., July, 1861.

The following investigation of the deflection of a suspension bridge due to a deflecting weight placed at an assigned point of the bridge, is applicable not only to the case of a chain of uniform thickness, but also to the more common case in practice of a chain of varying thickness. It is believed that no investigation of this subject has been published.

The method here adopted is necessarily approximative, as the formulæ of catenaries are so complex, that it would be impossible to treat the subject with rigorous exactness. But the closeness of the following approximation to the truth is probably quite sufficient for practi-

cal purposes. It will be here supposed that the points of suspension are fixed and of equal altitude; that the platform is perfectly flexible, and subject to no horizontal tension; that the deflecting weight produces a variation of the vertical distance of each point of the chain below the points of suspension, which is small compared with that distance; and that (as in practice) that distance is small compared with the horizontal span of the bridge.

Fig. 1.



Let the small arcs in Fig. 1 represent a small element of the length of the chain before and after the deflection respectively; R r the radii of curvature of those arcs; o o their centres of curvature; ds their length; $mgds$ their weight; $\theta\,\phi$ the inclinations of the radii of curvature to the horizon; T t the tangential tensions acting on the element before and after deflection respectively; C c the horizontal tensions before and after deflection respectively.

Then, since the horizontal tension at every part of a catenary is the same, $\mathrm{T}\sin.\theta = \mathrm{C}$; $t\sin.\phi = c$ (1)

The angles $\theta\,\phi$ differ little from each other. Also sin. θ, sin. ϕ do not greatly differ from unity, since the inclination of the chain to the horizontal is every where small. Consequently, $\frac{\sin.\theta}{\sin.\phi}$ differs from unity by a quantity which is small compared with unity.

Therefore, approximately, $\frac{\mathrm{T}}{t} = \frac{\mathrm{C}}{c}$ (2)

Resolving along the normal the forces acting on the element, we have, $\mathrm{T}\,d\theta = mg\,ds\sin.\theta$; $t\,d\phi = mg\,ds\sin.\phi$.

And as before, putting the ratio of sin. θ to sin. ϕ equal to unity.

$$\frac{\mathrm{T}}{t} = \frac{d\phi}{d\theta} \tag{3}$$

Therefore, from (2)

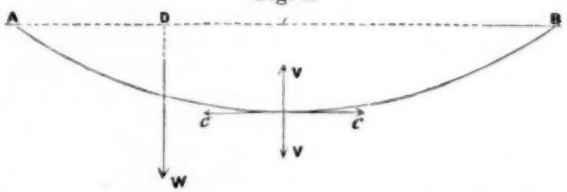
$$\frac{d\phi}{d\theta} = \frac{\mathrm{C}}{c},\ \text{and}\ d(\phi-\theta) = \frac{\mathrm{C}-c}{c}\,d\theta. \tag{4}$$

Integrating equation (4), $\phi - \theta = \frac{\mathrm{C}-c}{c}\theta + \text{a constant}.$ (5)

It is to be observed that m is not here assumed to be constant; so that the result is not confined to the common catenary. It may be added that the relation between θ and ϕ may be found by an integrable equation, without assuming sin. θ = sin. ϕ.

In order to determine this constant we may proceed as follows: Let the curve, Fig. 2, represent the deflected catenary; W the deflecting weight acting at an assigned horizontal distance A D = a from the point of suspension A. Let A C = C B = h. Let the depth below A B of the middle point of the chain be k. The tension at that point is not horizontal, but has a vertical component; let this be V. The horizontal

Fig. 2.



component we have already designated c. Let the half chain suspended from A have its centre of gravity at a horizontal distance b from A, and let S be the weight of the half chain. Then taking moments about A for the equilibrium of the half chain, we have,

$$W \cdot a + S \cdot b = c \cdot k + V h.$$

As the displacement of every part of the chain is small, the difference between the quantity k and the value of that quantity before deflection is small compared with k. The same consideration applies to b. We may therefore define k to be the depth below A B of the lowest point of the *undeflected* chain; and b to be the horizontal distance of the centre of gravity of either half of the *undeflected* chain from its point of suspension.

Taking moments about B for the equilibrium of the half chain suspended from B we have,

$$S \cdot b = c \cdot k - V h.$$

From the last two equations we get,

$$W \cdot a = 2 V \cdot h; \quad W \cdot a + 2 S \cdot b = 2 c \cdot k.$$

From the last equation, putting W = 0,

$$S \cdot b = C \cdot k. \quad \text{Therefore, } V \cdot h = (c - C) k.$$

Whence,
$$\frac{V \cdot h}{c \cdot k} = \frac{c - C}{c} \qquad (6)$$

Let a be the value of ϕ for that part of the chain which is horizontal before deflection. Since for that part of the chain $c = t$ sin. a, and $V = t$ cos. a,

$$\frac{V}{c} = \text{cotan. } a = \tan.\left(\frac{\pi}{2} - a\right) = \frac{\pi}{2} - a \text{ nearly,}$$

since a is nearly a right angle. Hence,

$$\frac{\pi}{2} - a = \frac{V}{c} = \frac{k}{h} \cdot \frac{c - C}{c} \qquad (7)$$

Returning now to equation (5), we have, when θ is a right angle and $\phi = a$,

$$a - \frac{\pi}{2} = -\frac{c - c}{c} \cdot \frac{\pi}{2} + \text{the constant.}$$

Therefore from (7) the constant $= \frac{c - c}{c}\left(\frac{\pi}{2} - \frac{k}{h}\right)$, and equation (5) becomes

$$\phi - \theta = \frac{c - c}{c}\left(\frac{\pi}{2} - \theta - \frac{k}{h}\right) \qquad (8)$$

Let the curve be referred to rectangular co-ordinates, the origin of co-ordinates being the lowest point of the undeflected chain, and the axis of x horizontal. Let x, y be the co-ordinates of the element before, $x'y'$ its co-ordinates after deflection.

$$\frac{dx}{ds} = \sin.\,\theta, \qquad \frac{dy}{ds} = \cos.\,\theta, \qquad \frac{dy'}{ds} = \cos.\,\phi,$$

$\cos.\,\phi = \cos.\,[(\phi - \theta) + \theta] = \cos.\,\theta - (\phi - \theta)\sin.\,\theta$ nearly, since $\phi - \theta$ is small.

Hence, from (8),

$$\frac{dy'}{ds} - \frac{dy}{ds} = -\frac{c - c}{c}\left(\frac{\pi}{2} - \theta - \frac{k}{h}\right)\sin.\,\theta. \qquad (9)$$

Now ds is equal to $R\,d\theta$, and since the radius of curvature is every where large and varies little, we may integrate the preceding equation, assuming R to be constant.

$$d\,(y' - y) = -R\,d\theta\,\frac{c - c}{c}\left(\frac{\pi}{2} - \theta - \frac{k}{h}\right)\sin.\,\theta.$$

$$y' - y = R\frac{c - c}{c}\left\{\left(\frac{\pi}{2} - \frac{k}{h}\right)\cos.\,\theta - \theta\cos.\,\theta + \sin.\,\theta\right\} + \text{a constant.}$$

Let the value of θ at the summit of the chain be β, then since at that point $y' - y$ is zero, we have from the last equation,

$$y' - y = R\frac{c - c}{c}\left\{\left(\frac{\pi}{2} - \frac{k}{h}\right)(\cos.\,\theta - \cos.\,\beta) - \theta\cos.\,\theta + \beta\cos.\,\beta + \sin.\,\theta - \sin.\,\beta\right\}$$

At the middle point of the chain where θ is a right angle and $\cos.\,\theta$ is zero, the deflection is

$$R\frac{c - c}{c}\left\{1 - \sin.\,\beta - \cos.\,\beta\left(\frac{\pi}{2} - \frac{k}{h} - \beta\right)\right\}$$

or, to express the deflection in terms of the inclination of the curve at its summit to the horizontal line, let the angle of that inclination be $\gamma = \frac{\pi}{2} - \beta$. Then the last mentioned deflection is

$$R\frac{c - c}{c}\left\{1 - \cos.\,\gamma - \sin.\,\gamma\left(\gamma - \frac{k}{h}\right)\right\}$$

When R is taken as constant, $R(1 - \cos.\gamma) = k$ and $R \sin.\gamma = h$. Hence we may readily show that $\sin.\gamma = \frac{2hk}{h^2 + k^2}$. Put $\sin.\gamma = \gamma$ in this expression, since γ is very small. Therefore the above expression for the deflection at the centre of the chain becomes

$$\frac{c - C}{c}\left\{k - h\left(\frac{2hk}{h^2 + k^2} - \frac{k}{h}\right)\right\} = \frac{c - C}{c} \cdot \frac{2k^3}{h^2 + k^2}$$

an expression from which the deflection at the centre is easily computed. The deflection at any other point may also be found from the general expression for the deflection by substituting for cos. θ, sin. θ, and θ their equivalents in terms of the rectangular co-ordinates of the point of which the deflection is required.

The mode of computing c and C is given by the equation (6). It may be observed that in practice these tensions may be computed with sufficient accuracy by assuming the centre of gravity of each half chain to act at a horizontal distance from the summit equal to the quarter-span. This is the position which the centre of gravity would have if each half of the chain were regarded as a straight uniform bar, and the deviation of that assumption from the truth produces no considerable error. We have then for the undeflected chain the following simple formula for the horizontal tension:

$$\frac{\text{Horizontal tension}}{\text{Weight of half chain}} = \frac{\text{quarter-span}}{\text{total rise of chain}}.$$

In the common catenary this result may be obtained analytically, for if the origin be at a distance c below the lowest point of the catenary, and

$$y = \frac{2}{c}\left(\varepsilon^{\frac{x}{c}} + \varepsilon^{-\frac{x}{c}}\right)$$

Since $\frac{x}{c}$ is very small, we have by expansion,

$$y = c + \frac{x^2}{2c} \text{ nearly, or } c \,.\, (y - c) = x \,.\, \frac{x}{2}$$

which is the equation which would be obtained by equating the moments about the summit of the forces acting on the half chain, and assuming the centre of gravity to have the position last mentioned. In ordinary suspension bridges, in which the chain is somewhat more massive at the highest points than at the centre, the same equation is approximately correct, for the variation of the massiveness of the chain is not great, and it brings the centre of gravity of the half chain rather nearer to the point of suspension than is the case in the common catenary, in which the centre of gravity is at a distance from that point somewhat greater than the quarter-span. From the last equation it appears that the catenary in practical cases is very near a parabola.

MECHANICS, PHYSICS, AND CHEMISTRY.

On Combustion in Rarefied Air. By Dr. EDWARD FRANKLAND, F. R. S.

In the autumn of 1859, whilst accompanying Dr. Tyndall to the summit of Mont Blanc, I undertook at his request some experiments on the effect of atmospheric pressure upon the amount of combustible matter consumed by a common candle. I found that, taking the average of five experiments, a stearine candle diminished in weight 9·4 grammes when burnt for an hour at Chamounix; whilst its ignition for the same length of time on the summit of Mont Blanc, perfectly protected from currents of air, reduced its weight to the extent of 9·2 grammes.

This close approximation to the former number under such a widely different atmospheric pressure, goes far to prove that the rate of combustion is entirely independent of the density of the atmosphere.

It is impossible to repeat these determinations in a satisfactory manner with artificially rarefied atmospheres, owing to the heating of the apparatus which surrounds the candle, and the consequent guttering and unequal combustion of the latter; but an experiment in which a sperm candle was burnt first in air under a pressure of 28·7 inches of mercury, and then in air at 9 inches pressure, other conditions being as similar as possible in the two experiments, the consumption of sperm was found to be,—

At pressure of 28·7 inches 7·85 grms. of sperm per hour.
" 9·0 " 9·10 " " "

thus confirming, for higher degrees of rarefaction, the result previously obtained.

In burning the candles upon the summit of Mont Blanc, I was much struck by the comparatively small amount of light which they emitted. The lower and blue portion of the flame, which under ordinary circumstances scarcely rises to within a quarter of an inch of the apex of the wick, now extended to the height of $\frac{1}{3}$th of an inch above the cotton, thus greatly reducing the size of the luminous portion of the flame.

On returning to England, I repeated the experiments under circumstances which enabled me to ascertain, by photometrical measurements, the extent of this loss of illuminating effect in rarefied air. The results prove that a great reduction in the illuminating power of a candle ensues when the candle is transferred from air at the ordinary atmospheric pressure to rarefied air. It was, however, found that, owing to the circumstances mentioned above, no satisfactory quantitative experiments could be made with candles in artificially rarefied air, and recourse was therefore had to coal-gas, which, although also liable to certain disturbing influences, yet yielded results, during an extensive series of experiments, exhibiting sufficient uniformity to render them worthy of confidence. The gas was in all cases passed through a governor to secure uniformity of pressure in the delivery tubes. A single jet of gas was employed as the standard of comparison, and this

was fixed at one end of a Bunsen's photometer, whilst the flame to be submitted to various pressures, and which I will call the experimental flame, was placed at the other. The experimental flame was made to burn a uniform amount of gas, viz. 0·65 cubic foot per hour in all the experiments.

The products of combustion were completely removed, so that the experimental flame, which burnt with perfect steadiness, was always surrounded with pure air, the supply of which was, however, so regulated as to secure a maximum of illuminating effect in each observation.

In all the following series of experiments, the illuminating power given under each pressure is the average of twenty observations, which accord with each other very closely. In each series, the maximum illuminating effect, that is the light given by the experimental flame when burning under the full atmospheric pressure, is assumed to be 100. The following is a summary of the results:

First Series.		Second Series.	
Pressure of air in inches of mercury.	Illuminating power of experimental flame.	Pressure of air in inches of mercury.	Illuminating power of experimental flame.
29·9	100·0	30·2	100 0
24·9	75·0	28·2	91·4
19·9	52·9	26·2	80·6
14·6	20·2	24·2	73 0
9·6	5·4	22·2	61·4
6·6	·9	20·2	47·8
		18·2	37·4
		16·2	29·4
		14·2	19 8
		12·2	12·5
		10·2	3·6

These numbers indicate that even the natural oscillations of atmospheric pressure must produce a considerable variation in the amount of light emitted by gas flames, and it was therefore important to determine, by a special series of observations, this variation in luminosity within, or nearly within, the usual fluctuations of the barometrical column. In order to attain greater delicacy in the pressure readings in these experiments, a water-gauge was used, but its indications are translated into inches of mercury in the following tabulated results, each of which represents, as before, the average of twenty observations.

Third Series.

Pr. of air in ins. of mercury.	Illum. power of exp. flame.
30·2	100·0
29·2	95·0
28·2	89·7
27·2	84·4

It is thus evident that the combustion of an amount of gas which

would give a light equal to 100 candles when the barometer stands at 31 ins., would give a light equal to only 84·4 candles if the barometer fell to 28 ins.

An inspection of all the above results shows that the rarefaction of air, from atmospheric pressure downwards, produces a uniformly diminishing illuminating power until the pressure is reduced to about 14 ins. of mercury, below which the diminution of light proceeds at a less rapid rate. The above determinations give approximately 5·1 per cent. as the mean reduction of light for each diminution of 1 in. of mercurial pressure down to 14 ins. The following table exhibits the actually observed light, compared with that calculated from this constant.

First Series.			Second Series.		
Pressure.	Illuminating power.		Pressure.	Illuminating power.	
	Observed.	Calculated.		Observed.	Calculated.
29·9	100 0	100·0	30·2	100·0	100 0
24·9	75·0	74·5	28·2	91·4	89·8
19·9	52·9	49·0	26·2	80·6	79·6
14·6	20·2	22·0	24·2	73·0	69·4
9 6	5·4	— 3·5	22·2	61·4	59·2
6 6	·9	— 18·8	20·2	47·8	49·0
			18·2	37·4	38·8
Third Series.			16·2	29·4	28·6
			14·2	19·8	18·4
			12·2	12·5	8·2
30·2	100·0	100.0	10·2	3 6	— 2·0
29·2	95·0	94·9			
28·2	89·7	89·8			
27·2	84·4	84·7			

I am now extending this inquiry to pressures exceeding that of the atmosphere, and hope soon to lay before the Society the detailed results of the whole series, together with some observations on the causes of this variation of luminosity.—*Proceedings of the Royal Society*, March 7, 1861.

The Russian Pacific Telegraph.

From the London Engineer, No. 279.

The plan for establishing a telegraphic line connecting Europe through Siberia with the Pacific Ocean has, during four years, had time to take shape and form, so that at the commencement of the present year, the supreme sanction was given to the project for constructing a telegraphic line in the countries bordering on the Amoor and Oussouri, from Nikolaiewsk by Khabarovka to the port of Novgorod (1900 versts), the most important point of the possessions recently annexed to Russia on the Sea of Japan. The establishment of this line is undertaken by the Ministry of Marine at its cost, and under its direction; and at the same time the superior direction of the means

of communication (Board of Works) has commenced the construction of a line starting from Kasan in the direction of Siberia, which proposes opening at the end of the present year a telegraphic communication from Kasan to Omsk (1900 versts), and to continue it afterwards to Irkutsk, a distance of 2475 versts from Omsk. Thus, probably within two or three years on the one side there will be telegraphic communication between Europe and Asia to Irkutsk, and, on the other hand, our new colonies on the Amoor and Oussouri will be connected with each other, and with our principal ports on the Japanese waters. Thus of the extent of 10,000 versts which the Siberian telegraph will embrace, there only remains the central portion, that of Irkutsk by Kiakhta to Kabarovka, about 3500 versts, where as yet nothing has been settled; but it is beyond a doubt that as soon as the works actually projected shall have been successfully completed this intermediate line will be constructed, and thus within four or five years at the latest the gigantic project of a telegraphic communication from Europe to the distant lands on the shores of the Pacific Ocean will be realized. The year 1861 promises to be a memorable one, if we consider the great questions which will receive a solution. Among those questions we must place the commencement of a durable connexion and the establishment of rapid communication between Siberia and civilized Europe, and the apparatus of the electric telegraph on the virgin shores of the Amoor and Sea of Japan. It seems needless to point out the importance and usefulness of so vast an extension of improved communication by the promoters of civilization and commerce. —*St. Petersburg Gazette.*

The Separation of Silver from Galena.

From the Lond. Chemical News, No. 47.

The usual mode of separating the silver contained in lead ore, or galena, is by reducing the whole to the metallic state, and then oxidizing the lead in a particular kind of furnace; and this is done either with or without the use of the crystallizing process of Mr. H. L. Pattinson, according to circumstances. But by this means a considerable loss occurs both in lead and fuel. To prevent this loss, I have for some time successfully employed a method of separating the silver from the galena itself, which I will now describe.

Galena consists, as is well known, of the sulphuret of lead, mixed with a variable proportion of the sulphuret of silver, and both these substances fuse together, or melt at a bright red heat. Now, it so happens that, when sulphuret of silver is fused with chloride of lead, what is called a double decomposition takes place; that is to say, chloride of silver and sulphuret of lead are formed. Consequently, if we fuse together a quantity of argentiferous galena and chloride of lead, we shall remove the whole of the silver from the galena, and replace it by sulphuret of lead. This, then, is my new process: I mix together the galena and chloride of lead in the proportion of 100 lbs. of galena, 1 lb. of chloride of lead, and 10 lbs. of chloride of sodium or common salt; or, if the galena be very argentiferous, I add a larger

amount of chloride of lead. The whole is then fused together, when the chloride of silver and common salt rise to the surface, and may be skimmed off, and the desilverized galena falls and may be run out from the bottom. The mixture of chloride of silver and salt may then be decomposed by lime and charcoal, or in any other manner, so as to reduce the silver and a portion of the surplus chloride of lead, by which a metallic mass will result, suitable for the operation of the "cupell." —*Bubhil.*

On the Cause of the Loss of Strength in Iron Wire when Heated.

By Mr. JOHN DAGLISH.

From the London Engineer, No. 266.

During the course of some experiments on the strength of iron, the results of which were recently published in the "Transactions" of this institute, it was observed that when iron wire was subjected to a red heat its tensile strength was greatly reduced, but that, under the same circumstances, iron chain remained uninjured. An extract from *The Engineer* was also given (vol. viii, p. 14), containing some experiments lately made with *cold rolled iron*, and an expression of opinion that the great increase in the tensile strength of this description of iron was owing to "*the effect of consolidation*," and that, when passed through a fire "*many of the pores, before consolidation, must be again opened, there arising a consequent diminution of the strength previously gained.*" Ordinary iron wire is drawn cold, and, passing through a similar process, may be considered to be similar in nature and structure to cold rolled iron, and it is also spoken of by eminent authorities as becoming "condensed and hardened" after passing a few times through the draw-plate; and that its greatly increased tensile strength is owing to this consolidation.

During late years much attention has been paid to the improvement of iron, not only by refining, de-carbonizing, and re-carbonizing, but also by adding small quantities of chemical substances, and considerable success seems to have been attained; at the same time, in some cases, the quantity of foreign matter used is so minute as to create surprise at the extraordinary results stated to have been arrived at by its use; and, again, careful analysis has proved that some excellent qualities of iron contain a considerable quantity of substances which were previously considered to be most prejudicial. Under these circumstances, it will be interesting rightly to ascertain the cause of the great variation in the tensile strength of iron wire after heating, for it is still the same material, without any change in its chemical nature or apparently in its bulk.

The generally received opinion of consolidation does not seem to the writer to be well founded. This ought to result, perhaps to a greater extent, when the iron is treated in a heated and softened state, than when drawn or rolled cold and hard, for it is natural to suppose that it would be equally readily compressed when in the former state, and it has still to undergo the contraction of cooling, which exerts a far greater consolidating force than any merely mechanical method.

If there is any permanent expansion in cold rolled more than in hot rolled iron after being heated red, the specific gravity of the body taken after and before ought to show it, and to find this the following experiments were made:

1.—Common Rolled Iron.—
A piece cut off a 3-inch rolled bar.

Before heating,	7·600	7·549
After heating,	7·602	7·554
Increase,	·002	·005

2.—Common Rolled Iron.—
A piece of ¼-inch bar.

Before heating,	7·582	7·579	7·579
After heating,	7·592	7·590	7·594
Increase,	·010	·011	·015

3.—Common Rolled and Hammered Iron.—
A piece cut off a large common bar, and reduced, by hammering whilst hot, to a ¼-inch rod.

Before heating,	7·611	7·625
After heating,	7·589	7·6
Decrease,	·002	·025

4.—Common Forged Iron.—
Cut off a piece of forged iron, and reduced, by hammering whilst hot, to a ¼-inch rod.

Before heating,	7·737	7·756
After heating,	7·696	7·737
Decrease,	·041	·019

5.—Common Iron Wire, ¼-inch.

Before heating,		7·650
After heating,		7·669
Increase,		·019

6.—¼-inch round hard drawn wire.

Before heating red,	7·577	7·589	7·571
After heating red,	7·555	7·580	7·559
Decrease,	·022	·009	·012

7.—Common Steel Wire, ¼-inch.

Before heating,		7·810
After heating,		7·814
Increase,		·004

8.—Blistered Steel.

Before heating,	7·829	7·827
After heating,	7·819	7·819
Decrease,	·010	·008

9.—Cast Steel.

Before heating,	7·804	7·833
After heating,	7·808	7·838
Increase,	·004	·005

It appears from the above, that heating does not alter the original specific gravity to the extent of more than $\frac{1}{300}$th, and although pretty regular for the same description of iron, it sometimes causes an increase, and sometimes a decrease in the specific gravity of different qualities of iron, and no regular law is exhibited.

It will be observed that the specific gravity of hard drawn wire (6 = 7·58) is less than that of forged iron (4 = 7·74), showing that in forging the iron is more consolidated than in drawing, although its tensile strength is much less.

In the former experiments a piece of ¾-inch chain, made from a bar of carefully forged scrap iron (spec. grav. = 7·74), broke on a strain of 15 tons; whilst similar chain, made out of a bar of best rolled iron (sc. crown) (spec. grav. = 7·56), bore 24 tons.

It must be concluded, therefore, that "consolidation or condensation" is not the cause of the greatly increased strength of cold drawn wire, nor is the injurious action of red heat owing to "opening the pores," but that these effects are owing to some change in the molecular structure of the iron, not accompanied by change of bulk, or otherwise sensibly apparent.

As bearing on the point, I may also mention, as stated in *The Engineer*, that the "iron of the great Mersey gun, portions of which were

tested at Woolwich, whilst it showed a strength of 50,624 lbs. in the direction of the grain, bore only 43,339 lbs. when strained across the grain.

The Strength of Wire Ropes and Chains.—Discussion on Mr. Daglish's Paper.*

From the London Engineer, No. 266.

Mr. DAGLISH said—Since this paper was written, the following account of some experiments on cold rolled iron has appeared in *The Engineer*, which corroborate the views of the writer as to the great loss of strength in iron wire when heated to a high temperature, and of the little effect which the same treatment has on iron chains. The latter being rolled hot does not suffer any change in its molecular constitution by the application of a high heat, whilst the former having been drawn cold seems to undergo a change of structure which greatly injures its tenacity. The following are the observations alluded to:—"During the week certain of the iron-masters of South Staffordshire have been informed of the results of a series of experiments that have just been made by Mr. William Fairbairn, of Manchester, upon the tensile strength of bars of wrought iron, some of which have been subjected to a process of cold rolling, invented by Mr. Lauth, and in operation at Mr. Nasmyth's works, Patricroft. The first experiment was on a bar of wrought iron, in the condition in which it is received from the manufacturer (black). The diameter of the piece experimented upon was 1·07 in.; its area 0·85873 square inch. The laying-on of a weight of 46,426 lbs. produced an elongation on a length of 10 ins. to the extent of 1·30 in.; and the laying-on of 50,346 lbs. produced an elongation of 2·00, with a breaking weight per square inch of, in pounds, 58,628, and in tons, 26·173. The diameter at the point of fracture, after this experiment, was 0·88 in. The second experiment was on a bar similar to the preceding, but rolled cold. Diameter, 1·00 in.; area, 0·7854 square inch. With a weight of 64,255 lbs. laid on, it elongated rapidly, and the breaking weight was per square inch, in pounds, 81,812, and in tons, 36,523. The third experiment was also on a bar of iron rolled cold, with a diameter and area similar to the foregoing. The elongation of a length of 10 ins. was, in inches, 0·6, when a weight of 62,545 lbs. was laid on. With 69,295 lbs. laid on, the elongation was 0·79 in., and the breaking weight per square inch 88,230 lbs., in tons 39·388. The diameter after fracture was 0·85. The fourth experiment was on a bar of similar iron to the preceding, turned in a lathe. Diameter and area same as in the two foregoing. With a weight laid on of 30,910 lbs. the elongation was 0·15, and 2·20 with a weight of 47,710 lbs. Here the breaking weight per square inch was, in pounds, 60,746, in tons, 27,119. The diameter after fracture was 0·80. Thus it will be seen, that in an untouched or black bar the breaking weight was 50,346 lbs.; per square inch 58,628 lbs., or 26·173 tons strength, the untouched bar being unity, 1·000. That the breaking weight of a bar rolled cold was 69,295 lbs.; per square inch 88,230 lbs., or 39·388 in tons strength, the untouched

* Northern Institute of Mining Engineers.

bar being unity, 1·505. The breaking weight of a turned bar was 47,710 lbs.; the breaking weight per square inch 60,746 lbs., or 27·119 in tons strength, the untouched bar being unity, 1·006. From this it is evident that the effect of consolidation by the process of cold rolling is to increase the tensile powers of resistance from 26·17 tons per square inch to 39·38 tons, being in the ratio of 1 : 1·5, one-half increase of strength gained by the new process of cold rolling. When, however, the iron rolled cold has repassed through the fire, many of the pores before consolidated must again be opened, there arising a consequent diminution of the strength previously gained. This being the case, no use immediately occurs to us to which the bar so rolled cold can be applied with the advantage that the process must secure to the tie rod now so much used in supporting roofs in particular. Here the only portions that need be subjected to the fire are the eyes, always extra welded to maintain the same strength throughout."

From these experiments, it would seem that a 1-in. bar of hot rolled iron bore 26 tons, and the same iron when rolled cold bore 36½ tons per square inch. This agreed with his experiments on the effects of heating iron wire. He found that the strength of the wire, when heated, was reduced one-half. Wire was drawn cold, and by heating it was weakened. The same results did not apply to chains, because the iron was rolled hot, and when heated afterwards was not injured.

Mr. Berkley: Can you speak of the effect of different degrees of heat? Take the effect on ropes used in an upcast shaft, where the heat is generally considerable. What effect has such heat on wire ropes?

Mr. Daglish: The cause of the great injury done to wire ropes opposite to the exit of the furnace drift, is not owing to the direct action of the heat of the furnace itself, but to the chemical effect of its vapors principally in action at this point. The sulphur in the coals, volatilized by the furnace, combines with a portion of oxygen to form sulphurous acid, this, possessing the property of taking up another atom of oxygen when in contact with moist air, forms hydrated sulphuric acid in the upcast shaft, which, diluted with the other shaft water, passes down the rope, and as the boiling point of hydrated sulphuric acid is greatly higher than that of water, the solution increases in strength as it falls down the shaft, and becomes highly concentrated and corrosive when opposite the furnace drift, and subjected to a temperature of probably 300 degrees. Water after passing down a deep and moist upcast shaft is sensibly acid to the taste, and reddens litmus paper.

Mr. Barkus: The action of moisture upon iron in an upcast shaft is well known to have a very serious effect on wire ropes.

The President: The effect is very much increased upon that part of the rope which is stationary, immediately opposite the entrance of the furnace drift into the shaft. It is at this place where the heat is greatest, and the force of the current of air issuing out of the furnace drift striking upon the wire rope at the time the rope is stationary, which it is for a short time when the tubs are being taken out of and put into the cages, at the top and bottom of the pit.

Mr. Berkley: The effect of the heat is to evaporate the water or moisture on the rope, and to produce oxidation. Another element to be considered is the weight and effect on the chain. Where one link presses against another link the oxidation is produced more rapidly when heated by the furnace of the upcast shaft than when it is perfectly cold.

Mr. Barkus: Another circumstance operates on wire ropes by the action of the furnace in an upcast shaft. The heated air projected against the rope at the mouth of the furnace drift expands it considerably. The rope then passes rapidly into a cooler medium, and ultimately to the temperature of the atmosphere on the surface. The transition from a temperature of probably 300° to 40° or 50° produces a continual motion, or change, or alteration of the particles of the wire, and ultimately almost entirely destroys their cohesion, and the wire becomes brittle and rigid.

Mr. Daglish: The most injurious effect of the heat and moisture on ropes in upcast shafts is owing, as I have stated, to the formation of sulphuric acid. I have found in analyzing the water, that, after partial evaporation, the remaining portion was very strong acid, sufficiently so to corrode iron very rapidly, and consequently, the effect, both on the ropes and chains, is very great indeed.*

* The following conclusive experiments have since been made to test this:

		Cwt.	qr.	lb.	
1.	Single wire,	6	2	24	New wire; broken by suspending weights to them.
	Do.	6	3	10	
	Do.	6	1	24	
		6	2	19	
2.	Do.	7	0	10	Suspended for a month in the dry furnace staple at Seaton Colliery. Temperature 250 deg.
	Do.	6	3	8	
	Do.	6	3	24	
		6	3	23	

The heat, therefore, in an upcast shaft, is not sufficiently high to injure the wires of a rope.

To judge the effect of the acid water, resulting from the oxidation of the sulphur in the coals used at the furnace, three pieces, similar so the last, were hung in the wet upcast shaft.

		Cwt.	qr.	lb.	
3.	Single wire (same as 1 and 2),	5	1	0	Hung in the wet upcast shaft for twenty-eight days. Temperature 150 deg.
	Do.	4	3	10	
	Do.	4	1	10	
		4	3	10	

Showing a loss of 30 per cent.

The following additional experiments have also been made:

		Cwt.	qr.	lb.	
1.	¾-in. round common iron,	31	0	1	Broken by suspending weights.
	Do. do.	30	0	1	
	Do. do.	31	1	1	
		30	3	1	
2.	Do. do.	30	1	8	Heated to a strong red in blacksmith's fire.
	Do. do.	29	2	22	
	Do. do.	29	2	1	
		29	3	10	
3.	Do. do.	29	3	19	Hung in Seaton furnace dry staple for a month. Temperature 250 deg.
	Do. do.	30	1	12	
	Do. do.	29	1	14	
		29	3	15	
4.	Do. do.	a 26	2	4	Hung in Seaton upcast shaft for a month; much damaged and eaten by acid. Temperature 150 deg.
	Do. do.	b 18	0	14	
	Do. do.	c 28	0	0	

Nos. 2 and 3, as compared with No. 1, prove that common rolled iron is uninjured by being subjected to a

Results of Experiments on the Strength, &c., of R. S. Newall & Co.'s Steel Wire Ropes, with a Chain-Testing Machine, in Mr. A. M'Vicar's Chain Works, Greenock, 14th March, 1859. Present—Robert Steel, Esq.; Laurence Hill, Esq.; John Galloway, Esq.; Mr. Wm. M'Millan; Mr. John Hastie, Engineer; and others.

		At a load of	Stretch in 6 ft.	Permanent stretch in 6 ft.	Broke after lifting.
		Tons.	Inch.	Inch.	Tons.
3 Pieces, each 1 15-16 inch circumference, and weighing 3·07 lbs. per fathom, . .	1st Piece.	10	$\frac{3}{8}$		
		12	11-16	$\frac{1}{16}$	
		15	$1\frac{3}{8}$	$\frac{3}{8}$	15
	2d "	—	—	—	15
	3d "	—	—	—	15
3 Pieces, each 2 1-16 inch circumference, and weighing 3·59 lbs. per fathom, . .	1st "	8	$\frac{3}{8}$		
		12	9-16	$\frac{1}{16}$	
		15	15-16	$\frac{1}{4}$	16·25
	2d "	—	—	—	16·50
	3d "	—	—	—	16·75
3 Pieces, each $2\frac{3}{8}$ inch circumference, and weighing 4·67 lbs. per fathom, . . .	1st "	5			
		8	$\frac{1}{4}$		
		10	$\frac{1}{4}$		
		14	$\frac{3}{8}$	$\frac{1}{16}$	
		17·5	$\frac{3}{8}$	$\frac{1}{4}$	25
	2d "	—	—	—	25
	3d "	—	—	—	25
3 Pieces, each $2\frac{5}{8}$ inch circumference, and weighing 5·74 lbs. per fathom, . . .	1st "	5			
		9	$\frac{3}{8}$		
		12	7-16	$\frac{1}{16}$	
		15	$\frac{3}{8}$	$\frac{1}{4}$	
		17·5	11-16	$\frac{1}{4}$	
		20	$\frac{1}{2}$	$\frac{1}{4}$	28·75
	2d "	—	—	—	28·50
	3d "	—	—	—	27·50
3 Pieces, each 3 inch circumference, and weighing 7·55 lbs. per fathom, . . .	1st "	6	$\frac{1}{4}$		
		10	$\frac{1}{4}$		
		14	$\frac{3}{8}$	1-16	
		18	$\frac{1}{2}$	1-16	
		25	$\frac{1}{2}$	5-16	34
	2d "	—	—	—	34·25
	3d "	—	—	—	34·50

The following best Charcoal Iron Wire Ropes were tested at the same time, and the results were:

1 Piece, $1\frac{7}{8}$	inch circumference,	3	lbs. per fathom,	. .	6
1 " $2\frac{1}{4}$	" "	7	" "	. .	16
1 " $3\frac{3}{8}$	" "	9	" "	. .	20
1 " $3\frac{3}{8}$	" "	9	" "	. .	21·25
1 " $3\frac{1}{2}$	" "	10	" "	. .	22·50

high temperature, and are corroborative of the previous experiments. No. 4 also shows the injurious effect of moisture in an upcast shaft: the centre piece (*b*) was most exposed to the action of the acid water.

In order to ascertain the amount of free acid in the water in an upcast furnace shaft, a portion, taken out of the Seaton shaft near to the exit of the furnace drift, and about 220 fathoms from the surface, has been tested by Mr. Lindsay Wood and myself. We find it to contain about one grain of sulphuric acid (SO_3, HO) in 700, or about ·14 per cent. About eight tons of small coals are consumed by the furnace in twenty-four hours.

Mr. Boyd: Have you any analytical experiments on wire made from cold drawn wire after it has been heated?

Mr. Daglish: There is no chemical change by merely heating iron. There is a change in the molecular arrangement.

The President: Have you any further observation to make as to steel wire ropes?

Mr. Daglish: I have given the result of two experiments made myself with steel wire ropes, and I have been furnished with a copy of some experiments made recently at Greenock, which have not been published, but seem to be well authenticated. In reference to the splicing of wire ropes and to the effect of broken wires, several experiments were made, I believe at Wingate Grange, some years since; one of these agrees very closely with mine; each wire in a strand of six wires was cut 12 inches apart. The strand then bore 12 cwts.

Wooden Substitutes for Whalebone.

From the London Chemical News, No. 47.

Many unsuccessful attempts have been made to obtain a perfect substitute for whalebone for the manufacture of the ribs of umbrellas and parasols. A Mr. Ball has found that by selecting the butt end of white oak timber, of what is termed the "second growth," and of straight rib and free from knots or curls, and, in no case, using more than six feet from the ground or stump, and subjecting it to a certain process of curing, it is made to serve not merely as a substitute for whalebone, but is converted into an altogether superior article, as it is not only tougher and possesses greater tenacity than whalebone, but the ribs made from it always resume their straight condition after exposure to the weather.

Melting Zinc by Gas.

From the London Chemical News, No. 47.

The melting of zinc, which is generally performed in plumbago crucibles over a coke fire, requires an elevated temperature that is difficult to regulate. If the temperature becomes too high, it causes a loss of zinc by evaporation and burning, and it also seriously injures the quality of that which remains; the oxide of zinc resulting from combustion mixing mechanically among the metallic mass and producing what is termed burnt zinc. This accident occurring daily in zinc foundries, aroused the attention of Mr. Miroy to the advantages of employing gas in this operation. His apparatus consists of a cast iron crucible placed upon an upright cylinder in a conical furnace, where the gas is burned. This furnace is formed of two concentric envelopes of iron plates, separated by a layer of sand; or it may be of fire-brick. The gas is brought in obliquely from the two sides by two pipes, each concentric to a larger pipe, leading compressed air; the gas-pipe being ·6 of an inch in diameter, and the air-pipes being 2·8 inches. Mr. Miroy estimates that the volume of air employed should be triple that

of the gas, and this proportion is regulated by stop-cocks in the pipes. The air is forced into the pipes by a blower driven by a power. The melting by gas is more rapid and less costly than the fusion by coke, especially when a crucible has to be mounted for a single melting. There is also a great saving in the cost of crucibles.

For the Journal of the Franklin Institute.

Strength of Materials: Deduced from the latest experiments of Barlow, Buchanan, Fairbairn, Hodgkinson, Stephenson, Major Wade, U. S. Ordnance Corps, and others. By CHAS. H. HASWELL, Civil and Marine Engineer.

No. 10.—(*Continued.*)

EFFECT OF IMPACT ON CAST AND WROUGHT IRON.

(Continued from page 127.)

Horizontal and Vertical.—The power of a bar, beam, &c., to resist impact varies with the mass of the bar, &c., the striking body being the same, and by increasing the inertia of the bar, &c., without adding to its strength, the power to resist impact is, within certain limits, also increased.

Hence, weight is an important element in structures exposed to concussion.

If blows of equal magnitude are given upon the middle of a bar, beam, &c., either by elastic or inelastic bodies of the same weight, the same effect will be produced.

The *resilience*, or power of springing back of a bar, beam, &c., resisting a transverse impulse, follows a law very different from that determining its transverse strength, as it is simply proportional to the bulk or weight of the bar, &c., without any reference to the form of the section of it, or whether it is solid or hollow.

Thus, a bar, &c., 10 ft. in length will support but half the load without breaking that one of the same breadth and depth which is 5 ft. in length; but it will bear the impulse of a double weight striking against it with a given velocity, and will require that a given body should have a double momentum to break it.

The ultimate deflections of bars of different sections, struck with like weights and velocities of them, will differ in the proportion of the product of the squares of the section in the direction of the impact and the dimension of the section perpendicular thereto.

The ultimate breaking deflection of bars, &c., of like dimensions of section compared with others having twice the length between their supports, is somewhat greater than one-fourth, and the vertical* distance fallen through by the body of impact, to produce fracture is somewhat more than one-half.

Hence, the depth fallen through to break the bar of half the length, is nearly half of that required to break the bar of whole length.

When bars, &c., are struck in the middle between the centre and one support, the chords of impact necessary to produce fracture are

* The versed sine of the arc described by the oscillation, or swinging of a body of impact.

nearly equal in both cases and the ratio of the deflections from equal impacts are nearly constant under different increasing degrees of impact; the deflections from the centre between the supports from equal impacts, being to those at one-fourth the distance as 10 to 7 nearly.

With bars, &c., of like dimensions and distance between their supports, struck with balls of different weights, the ultimate deflection is very nearly equal, but the vertical descent of the ball is very nearly in the inverse ratio of the square of the weight.

In cast iron bars, &c., the deflections are greater than, in proportion to the velocity of impact; whilst in wrought iron they are very nearly constant with impacts of different velocities.

Bars, &c., when uniformly loaded, resisted greater impacts from like weights than when unloaded; in same proportion of loading, the resistances were as 2 to 1.

From a number of experiments on the impact of cast iron bars, it appeared that but a very few of them withstood 4000 blows, each deflecting them through half of their ultimate deflection; but all the bars when sound withstood this number of blows, each deflecting them through one-half of their ultimate deflection.

Bars, beams, &c., subjected to a regular depression equal to the deflection due to a load of one-third of their statical breaking weight, will bear 10,000 successive depressions, and when broken by statical weights will bear as great a resistance as like bars subjected to a like deflection by statical weight.

TABLE *of the Results of Experiments on the Continued Impact of Cast and Wrought Iron Bars.*—(Rep. of Com. on Railway Structures.)

IMPACT AND MATERIAL.	Distance between the supports.	Weight of striking ball.	Radius of arc of oscillation of ball.	Dimensions of Bar.		Weight of bar between supports.	Ultimate deflection.	Set.	Chord of arc of impact.	Height fallen through by ball at each blow.	Velocity of impact of ball per second.	Ultimate work done by the ball.	Breaking weight of like bar by vertical transverse pressure.	Ultimate deflection by breaking vertical pressure.
				In deflection of impact.	Perpendicular to impact.									
Horizontal.	Feet.	lbs.	Feet.	Inch.	Inch.	lbs.	Inch.	Inch.	Inch.	Feet.	Feet.	lbs.	lbs.	Inch.
Cast Iron.	13·5	603	17·5	3·046	3·036	378	4·875	·783	79	1·238	8·925	747	3000	4·55
	13·5	603	17·5	1·53	6·122	381	9·	1·320	78	1·207	8·812	728	1500	
	13·5	603	17·5	6·095	1·538	844	2·4	2·635	80	1·270	9·038	766	6000	
	6·75	603	17·5	3·	3·	193	1·23	·164	56·75	·639	6·411	385	6000	1·272
	9·	151·3	17·5	2·012	1·983	108	2·75	·296	80·5	1·286	9·094	194	750	
	9·	75·5	17·5	1·974	2·001	106	2·83	·320	124·	3·051	14·008	220	750	
Wrou't Iron.	4·5	75·5	17·5	2·	2·	54	·892	·131	98·5	1·925	11·128	145	1500	
	13·5	151·3	17·5	1·515	5·523	372	3·	·040	119·8	2·845	13·528	430	—	
	13·5	603	17·5	1·515	5·523	372	4·	—	61·18	·743	6·913	448	—	
Vertical.	13·5	303	—	1·522	5·018	338	5·182	3·82	—	3·	13·892	909	—	
C'st iron	13·5	303	—	3·	3·	382	3·745†	—	—	2·625	12·995	795	3000	4·55
	13·5	303	—	3·	3·	779*	3·786†	—	—	3·5	15·005	1060	3000	4·55
	13·5	303	—	3· ..	3·	1343*	3·338†	—	—	4·5	17·015	1363	3000	4·55

* Loaded uniformly with additional weight.
† Broke at impacts due to a height of 33, 45, and 60 feet, respectively.

To ascertain the Weight of the Body of Impact that can be sustained by a Rectangular Bar, &c., of Cast Iron.

When the Velocity of the Body, the area and length of the Bar, &c., are given.

RULE.—Divide the product of 45 times the length between the sup-

ports of the bar in feet by the area of the section in inches, by the square of the velocity of the body of impact in feet per second, and the quotient is the weight required.

Or, $$\frac{45\ l\ b\ d}{v^2} = \text{W}.$$

EXAMPLE.—A beam of cast iron 13·5 ft. in length between its supports and 3 ins., square is struck by a ball with a velocity of 10 ft. per second: what is the weight of the ball?

$$\frac{45 \times 13{\cdot}5 \times 3 \times 3}{10^2} = \frac{5467{\cdot}5}{100} = 54{\cdot}675 \textit{ lbs.; the weight of the ball.}$$

When the Height of the Fall is given.

Proceed as when the velocity is given, substituting for it 64·3 times the height of the fall.

To ascertain the area of a Cast Iron Beam that can sustain a given Impact.

When the Velocity and Weight of the Body of Impact and the Length of the Beam are given.

$$\frac{v^2\ \text{W}}{45\ l} = b\ d.$$

To ascertain the Velocity of the Body of Impact that can be sustained by a Cast Iron Beam.

When the Weight of the Body, the Length and Area of the Beam are given.

$$\frac{45\ l\ b\ d}{\text{W}} = v^2.$$

To ascertain the Weight of the Body of Impact on Cylinders, Grooved, and Open Beams of Cast Iron.

Grooved beam. $$\frac{45\ l\ b\ d\ (1 - q\ p^3)}{v^2} = \text{W}.$$

Open beam. $$\frac{45\ l\ b\ d\ (1 - p^3)}{v^2} = \text{W}.$$

Rectangular ellipse. $$\frac{58\ l\ b\ d}{v^2} = \text{W}.$$

Grooved ellipse. $$\frac{58\ l\ b\ d\ (1 - q\ p^3)}{v^2} = \text{W}.$$

Open ellipse. $$\frac{58\ l\ b\ d\ (1 - p^3)}{v^2} = \text{W}.$$

Results of Experiments to determine the Resistance of Cold and Hot Blast Irons to Vertical Impact.

The bars were of uniform dimensions, and were struck with a hammer when lying horizontally on supports.

Cold blast, . . 15 blows.
Hot " . 2 "

The power to resist impact, as determined by Mr. Fairbairn, upon

a number of specimens of English, Welsh, and Scotch irons, 1 inch square and 4·5 feet between the supports, the highest in the order of their powers of resistance to transverse stress, was a mean of 817.

On a new Method of Producing on Glass, Photographs or other Pictures, in Enamel Colors. By F. JOUBERT.

From the Journal of the Society of Arts, No. 444.

Of all the inventions to which the genius of man has given birth, and which have been progressively developed and brought by his industry to a high degree of perfection and usefulness, the art of glass-making is certainly one of the most interesting and extraordinary; at the same time as it is doubtless one which has tended to increase our comforts and our enjoyments in a degree almost unequalled by any other discovery of modern civilization.

If we look back to the dark ages, and find that in those days even the rulers of the earth had no means of keeping rain and bad weather from their habitations, except by also shutting out the light, we shall be ready to acknowledge the astonishing results, as compared with the present state of things around us, which the persevering efforts of man have, under the guidance of an ever-merciful Providence, been able to accomplish.

Before entering into the description of the process which is more immediately the subject of our meeting this evening, I would in a concise manner, and, as far as the necessarily limited time I have to occupy this place will allow me, recapitulate the history and progress of the invention of glass itself, and of glass painting which has led to the process before us.

We have no distinct evidence to show what nation first used glass, and we must therefore be satisfied with the various traditions transmitted to us from age to age, on the subject. One fact, however, seems established beyond the possibility of a doubt, viz: that the greatest antiquity can be assigned to this invention, since the Egyptians and the Phœnicians had both vessels and ornaments made of glass, crude in form, but of a substance so perfect, by whatever means obtained, that it has stood the trial of several thousand years, and may be pronounced to have suffered no deterioration. Might we not, in consequence, assign to glass a place in the list of useful inventions far higher than that which it occupies? for in this we have a discovery, the first inventors of which seem to have attained, at once, the very condition—durability—which humankind is incessantly bent upon obtaining for any produce of its hands.

But still more remote is the mention of glass in the Holy Scripture; for, if the interpretation of the text be a correct one, in the 18th chapter of Job, as also in several other parts of the Bible, is found an allusion to a substance which we imagine must have been glass. Next to this, Alexander Aphrodisius amongst the ancient Greeks, Lucretius, Flavius Vopiscus, and other Latin authors, have left us a correct description of glass. Aristophanes also alludes to glass in one of his

plays, and Aristotle brings out two problems on the subject: the first, why is it we see through glass? the second, why can we not bend glass?

Admitting that these two propositions emanate from the celebrated philosopher, they appear to give conclusive evidence that glass was familiar to the Greeks.

But we may, perhaps, even trace the origin of this invention far earlier, and to the remotest period of the existence of man, by associating it with the art of making bricks, which was, it is believed, practised by the earliest inhabitants of the earth; and it is not difficult to imagine how such an art would originate.

Man was led, for his subsistence, to seek a mode of preparing animal food for his use by roasting it over the fire, and having, in the course of time, built, rudely, a sort of oven made of earth, and the earth having become hardened through the action of the fire, our forefathers would soon discover all the advantages which might be derived from such a process for making bricks or pots, and utensils for common use. Specimens of the potter's art in ancient times we have in plenty, and in a variety of forms or shapes, which for elegance have not been surpassed. We need only allude to the Etruscan vases in the collection of the British Museum.

In firing bricks it will not unfrequently happen that some kind of vitrification takes place in the bricks placed in the hottest part of the fire, and one might naturally suppose that one process would lead to the other; but such does not appear to have been the case, at any rate, for many centuries. Later, horn and skins were in use down to the third or fourth century of the Christian era, and oiled paper or mica was also used in lieu of window glass, nearly up to the time of the reign of Elizabeth. If we are to give credence to the narrative of Pliny, to accident alone, as in many other instances, are we indebted for the discovery of glass. Some traders, being weather-bound, landed on the banks of a river in Syria, and began to prepare a place in the sand for cooking their meals, after having gathered for fuel a great quantity of an herb, known there by the name of *kali*, which plant must have contained a large proportion of carbonate of soda, and this being mixed with the sand, yielded, through the agency of the fire, a sort of vitreous substance. Such is one of the accredited versions of the origin of glass.

Glass has at all times, until recently, been thought a substance of great importance, and even amongst the primitive inhabitants of South America, and of the Indian continent, who were, when first visited by the early European navigators, found to possess gold and silver ornaments in abundance, it is well known that the first discoverers of those countries who happened to land in search of food or water, had no difficulty in obtaining from the natives gold in exchange for some valueless pieces of glass, or a few glass beads which they would immediately use as an ornament round their necks or their wrists. As late as the middle of the last century, glass beads of various descriptions and of all sorts of colors, were extensively manufactured in France,

principally for exportation to the colonies of South America and the islands of the Pacific Ocean.

It may be said that although glass is an article of first necessity to us, it is at the same time one with the nature of which very few persons are well acquainted, and the learned have even been often at variance as to the exact classification glass ought to belong to. It is not a mineral, since it has never been found in a primitive state in any country, neither can it be placed in the vegetable kingdom.

Glass has become with us an article so singularly cheap and common, that we are apt to lose sight of its immensely diversified qualities; but if only considered from a philosophical point of view, we shall find that few of the substances which we have in daily use, either in a simple or compound state, can be compared to glass in point of importance and of usefulness. Firstly, unlike any mineral, it is inodorous and clean to the fingers, and does not lose any of its weight by usage or wear; it is always transparent, whether in a cold or a red-hot state; it can take any shape whatever while in a state of fusion, and it retains it absolutely after it has cooled. It is capable of receiving the highest polish, and of taking any colored tint, either on its surface or in its body; and it also has this peculiar and invaluable advantage that it does not retain the taste of any liquid or acid it may have contained; it is the most flexible of substances while in fusion, and becomes harder than any pure metal when once it has become cold; lastly, it is not liable to rust, nor to be consumed by fire.

The applications of glass are now so numerous that it is difficult to imagine any one branch of industry or of manufactory which could be carried on for a single day without the use of glass in one shape or another. To some of the most important amongst the sciences, such as chemistry, physics, astronomy, the use of glass is a matter of absolute necessity; and in proportion to the gradual and increasing requirements of these last-named sciences, especially astronomy, it will be found that the glass manufacturer has been obliged to perfect his mode of manipulation, and, by the aid of chemistry, has of late years obtained such magnificent results that the field for astronomical observation has thereby been considerably enlarged.

It appears that, although vessels made of glass had been in use for a considerable time previously, it was only about the third century of our era that glass began to be used for glazing windows. These consisted of an infinite number of small panes of various shapes, which were arranged so as to form certain designs for the ornamenting of windows in places of worship; glass having, on account of its rarity then, been almost, if not entirely, confined to that use.

St. Jerome, who wrote in the fourth century, speaks of glass in church windows; and Grégoire de Tours relates, two hundred years later, in the year 525, that a soldier of the army of the King of the Visigoths, which had invaded Auvergne, entered a church through a window, of which he broke the glass. Fortunatus, Bishop of Poictiers, towards the end of the seventh century, describes with admiration the painted windows of the Cathedral of Paris. St. Philibert, also in the

seventh century, had the windows of the celebrated Abbey of Jumièges on the banks of the Seine, near Rouen, decorated with glass.

At the beginning of the eighth century glass was unknown in England, and it was Wilfrid, Bishop of York, who died in 709, who first introduced glass into England, by sending for some glass-makers from France, according to a record kept to this day. A few years later, St. Bennet, Abbot of Wearmouth, wishing to decorate the windows of his monastery, sent for some glass-makers, also from France, for it appears, from some authentic records, that the art of decorating windows with glass was practised in several parts of France, especially in Normandy, long before it was adopted in other countries.

It would seem that the art of staining glass was very early discovered, although no date can be correctly assigned to the period when stained glass for church windows was first used. The practice generally adopted was to make a sort of mosaic design, by placing an infinite number of small pieces of colored glass together. This was in use for several centuries before the art of painting on glass, properly speaking, was discovered, which seems to have soon extensively spread and to have been cultivated by many excellent artists, to judge by the numerous specimens still in existence on the continent. But for the 16th century, so rich already in artistic talent, was reserved the glory of carrying glass painting to a degree of excellence which has never been equalled since, and the names of Jean Cousin and Bernard de Palissy will be honored forever, amongst the large phalanx of glass painters in all countries. The most remarkable painted windows, perhaps, in this country, are the windows of the various Colleges at Oxford, which were executed during the 17th century by Bernard Van Linge and his pupils. William Price also repaired some of the glass paintings in Queen's College, Oxford, and in Christ Church painted a remarkable composition from the designs of Sir James Thornhill. Besides these may be mentioned the windows of Lichfield Cathedral, and several other very ancient windows in Christ Church, and especially in the residence of the Dean of Westminster, near the Abbey.

Having been, for many years, professionally acquainted with printing in connexion with the fine arts, and having observed the immense development the new art of photography has taken, and the large field it has opened for representing all sorts of subjects, of animated, as well as still life, it occurred to me that if a means could be found to print the photographic image on glass, as easily as it is done on paper, and through the agency of some chemical composition which would admit of employing ceramic or vitrifiable colors, and burning them in, a great result would be attained, and a new and considerable branch of industrial art might thereby be opened. Considering the numerous and various attempts which have, from time to time, been made to introduce a substitute for glass painting in the decoration of houses, I believe it can be said that a want was generally felt for supplying the growing taste for pictorial decoration; for glass painting is an expensive process, and requires also a considerable time to obtain a perfect result. There is a process known as lithophany, or transpa-

rent china, or biscuit slabs, which are now made, in Germany principally, and some very good specimens can be seen, but although any kind of subjects, on a small scale, can thus be represented, and with a very good effect, the slabs are heavy and thick, and can never come into use as a substitute for glass painting. Some few years ago, a new mode, which was then termed "potichomany," was introduced, which had for a short time very great success—I allude to the mode of pasting colored prints inside a large glass bowl, or jar, and applying a thin layer of plaster of Paris, in a liquid state, so as to fix the paper firmly, and create an opaque back-ground, by giving substance to the whole, when seen from a distance. Some very good specimens of this were obtained, and it afforded for a time an agreeable occupation to many a young lady. Another mode has also been tried, and some very pretty results produced, by applying prints obtained by lithochromy, or lithographic printing in colors, on a pane of glass, and varnishing them at the back with copal or some such varnish; these will for some time resist the effects of the weather when placed in a window, and this is perhaps the nearest approach to glass painting in point of effect yet achieved, but practically it does not answer, for the varnish will not stand exposure to the weather from outside, and the constant cleaning glass requires, renders it liable to be injured, so that the design soon perishes.

In the mode which is now for the first time introduced, no such danger or liability need be feared, since the color has been firmly fixed in the substance of the glass by fire, and, being composed of the same elementary materials, has become part of the glass itself, and can only be destroyed by the glass being annihilated by breakage.

In order that the process may be very distinctly understood, I shall now describe it by reading that part of my specification which relates to the placing the image on the glass, fixing it, and passing it through the fire.

This invention has for its object improvements in reproducing photographic and other pictures, engravings, prints, devices, and designs, on the surfaces of glass, ceramic, and other substances requiring to be fired to fix the same thereon.

For this purpose, I proceed in the following way:—A piece of glass, which may be crown or flatted glass, being selected as free from defect as possible, is firstly well cleaned, and held horizontally while a certain liquid is poured on it. This liquid is composed of a saturated solution of bichromate of ammonia in the proportion of five parts, honey and albumen three parts of each, well mixed together, and thinned with from twenty to thirty parts of distilled water, the whole carefully filtered before using it. The preparation of the solution, and the mixing up with other ingredients, should be conducted in a room from which light is partially excluded, or under yellow light, the same as in photographic operating rooms, so that the sensitiveness of the solution may not be diminished or destroyed.

In order to obtain a perfect transfer of the image to be reproduced, the piece of glass coated with the solution, which has been properly

dried by means of a gas-stove (this will only occupy a few minutes) is placed face downwards on the subject to be copied in an ordinary pressure frame, such as is used for printing photographs.

The subject must be a positive picture on glass, or else on paper rendered transparent by waxing or other mode, and an exposure to the light will, in a few seconds, according to the state of the weather, show, on removing the coated glass from the pressure frame, a faintly indicated picture in a negative condition. To bring it out, an enamel color, in a very finely divided powder, is gently rubbed over with a soft brush until the whole composition or subject appears in a perfect positive form. It is then fixed by alcohol in which a small quantity of acid, either nitric or acetic, has been mixed, being poured over the whole surface and drained off at one corner.

When the alcohol has completely evaporated, which will generally be the case in a very short time, the glass is quietly immersed horizontally, in a large pan of clean water, and left until the chromic solution has dissolved off, and nothing remains besides the enamel color on the glass; it is then allowed to dry by itself near a heated stove, and when dry is ready to be placed in the kiln for firing.

It may be stated that enamel of any color can be used, and that by careful registering, a variety of colors can be printed one after the other, so as to obtain a perfect imitation of a picture; also that borders of any description can be subsequently added, such as those shown in the specimens on the table, without any liability to remove or even diminish the intensity of the color in the first firing.

It will be easy to perceive that this mode of obtaining an image on glass, in an absolutely permanent substance, and of any description, color, or size, may prove of considerable advantage and utility for the decoration of private houses, and also for public buildings. Now that, by means of the photographic art, the most correct views of any object or of any building or scene—even portraits—can be faithfully and easily obtained; when we see every day the results of the labors of photographers in all parts of the world, in the shape of beautiful prints; when we can be made acquainted, without leaving home, with the actual costume, habitations, scenery, manners almost, of all countries, for instance, China and Japan, which have but recently opened their doors to European civilization; when through the same means, we are able to see, for the first time, and the learned are able to translate from, the graphic reproduction with which photography furnishes us of those early inscriptions engraved on the rocks in Asia, and by the Egyptians on their splendid monuments, I need only point out the usefulness of the mode of fixing those images, in an indelible manner, for ornamental as well as for scientific purposes.

In large cities, like London, where houses are built so close to one another, in how many places may not the process become available, by enabling any one to introduce, for a very moderate expense, pleasing or instructive images where common plain ground glass is now used, to shut out the sight of a disagreeable object, a dead wall, or an

unpleasant neighbor, without diminishing the amount of light more than is convenient.

In the library, fitting subjects might be introduced on the windows by a judicious selection of the portraits of favorite authors, or of famous scenery at home or abroad. In the dining room, also, appropriate pictures could be selected, such as flowers, fruit, or game subjects, so disposed as to harmonize with the decoration of the room. Even for domestic purposes, for lamps or screens, or any object in glass, the process will be found useful, especially on account of its rapidity, which will enable the manufacturer to execute and to deliver an order at a very few days notice.

(To be Continued.)

Production of Valuable Manure from the Air. By MM. MARGUERITTE and DE SOURDEVAL.

From the London Chemical News, No. 46.

The value of guano and most other concentrated manures consists to a considerable extent of the ammonia which they contain. As three-quarters of the atmospheric air consists of nitrogen, and as hydrogen forms one-ninth of all pure water, if some cheap means could be found for inducing the hydrogen of water to enter into combination with the nitrogen of the air in the form of ammonia, this valuable manure could be produced in unlimited quantities, and the agricultural products of the world enormously increased. The efforts to do this have been, at last, crowned with success, as will be seen by the following abstract of some recent continental researches.

Since the remarkable labors of Messrs. Liebig, Schaltenmann, and Kuhlmann, on the fertilizing action of ammoniacal salts, the production of ammonia at a low price has become a problem of the highest interest to agriculture. But to arrive at this result it is necessary to obtain the nitrogen elsewhere than in nitrogeneous matters; which may, for the most part, be employed directly as manures, and of which the limited quantities and elevated price permits in any event only restricted and costly manufacture.

Atmospheric air is an inexhaustible and gratuitous source of nitrogen. However, this element presents so great an indifference in its chemical reactions, that, notwithstanding the numerous attempts which have been made, chemists have not heretofore succeeded in combining it with hydrogen so as to produce ammonia, artificially. This result, so long desired, has been reserved for MM. Margueritte and De Sourdeval, who have obtained it by employing an agent of which the remarkable properties and neat and precise reactions have permitted them to succeed where all others have failed. This agent is baryta, of which notice has recently been taken on account of the recent applications that M. Kuhlmann has made of it in painting, but of which no person suspected the part that it was to be called to play in the development of the agricultural riches of our country. The manufac-

ture of ammonia is based on a fact entirely new, the cyanuration of barium. It had been believed until the present time that potash and soda alone had the property of determining the formation of cyanogen; that the earthy alkaline bases—baryta, for example, could not, in any case, form cyanides.

Messrs. Margueritte and De Sourdeval have ascertained that this opinion is entirely erroneous, and that baryta, much better than potash or soda, fixes the nitrogen of the air or of animal matters in considerable proportions. It is already understood that, for the preparation of Prussian blue, the cyanide of barium presents great advantages over that of potassium, for the equivalent of baryta costs only about the one-seventh of that of potash. Thus do we find practically and really obtained the result first announced by Desfosses and vainly pursued in France and England, the manufacture of cyanides from the nitrogen of the atmospheric air. This solution, so important, depends on the essential difference which exists between the properties of baryta and those of potash; the first is infusible, fixed, porous, and becomes deeply cyanuretted without loss; the second is fusible, volatile, and becomes cyanuretted only at the surface, and suffers by volatilization a loss which amounts to 50 per cent. After the cyanide of barium was obtained, the grand problem for Messrs. Margueritte and De Sourdeval to resolve was the transformation of the cyanide into ammonia by means at the same time simple, rapid, and inexpensive. The following is the operation:

In an earthen retort is calcined, at an elevated and sustained temperature, a mixture of carbonate of baryta, iron filings in the proportion of about 30 per cent., the refuse of coal tar, and saw-dust. This produces a reduction to the state of anhydrous baryta, of the greater part of the carbonate employed. Afterwards is slowly passed a current of air across the porous mass, the oxygen of which is converted into carbonic oxide by its passage over a column of incandescent charcoal, while its nitrogen, in presence of the charcoal and of the barium, transforms itself into cyanogen and produces considerable quantities of cyanide. In effect, the matter sheltered from the air and cooled, and washed with boiling water, gives with the salts of iron an abundant precipitate of Prussian blue. The mixture thus calcined and cyanuretted is received into a cylinder of either cast or wrought iron, which serves both as an extinguisher and as an apparatus for the transformation of the cyanuret. Through this cylinder, at a temperature less than 300° (Centigrade) is passed a current of steam, which disengages, under the form of ammonia, all the nitrogen contained in the cyanide of barium. It is impossible to foresee all the results of this great discovery. Among other things, it suggests the production of nitric acid from the air by oxidizing ammonia.

THE whole ordinary pressure upon all the internal surfaces of a locomotive boiler of the largest class (including the tubes) is about 15,000 tons.

*On the Preparation of Artificial Coloring Matters with the Products Extracted from Coal Tar.** By M. E. Kopp.

From the Lond. Chemical News, No. 38.

The dry distillation of organic matters, whether vegetable or animal, from the great variety of products to which it gives rise, constitutes one of the most interesting operations of chemistry. The reactions to which these products owe their origin are very complex, and some of them have been but little studied, as indeed is the case with many of the substances formed. If the body submitted to dry distillation could be maintained during the operation under uniform conditions of desiccation, temperature, and pressure, the reactions and the products would be much more simple. If, for example, wood be heated very slowly in close vessels, first to 100° C., then to 200°, 300°, and so on, there is at first disengaged almost pure water, then impure strong acetic acid, and afterwards a mixture of acetone and acetate of methylene; the maximum of charcoal is left as residue, and the least amount of tar and gas is produced, the latter consisting only of carbonic acid and carburetted hydrogen.

In practice, however, when wood is distilled in cylinders of iron heated from the outside, the heat only penetrates to the interior gradually. The outside layers are therefore the first decomposed; they at first lose water, then furnish pyroligneous acid and wood-spirit, at the same time giving off carbonic acid and a little carburetted hydrogen. The inner layers in turn are similarly decomposed; but the products as they are given off are brought into contact with the outer layer, already in a more advanced state of decomposition and at a much higher temperature, and hence new reactions take place and new products are formed. Thus, the vapor of water in contact with red hot charcoal is decomposed, and forms carbonic acid and hydrogen; a part of the carbonic acid is again decomposed by the red hot carbon to form some carbonic oxide; a part of the nascent hydrogen combines with carbon to form various hydrocarbons; one part of the acetic acid is decomposed by the high temperature to form acetone and carbonic acid; another part reacts on the wood-spirit and forms methylic acetate; a fraction of the wood-spirit and acetone are also decomposed, producing tarry matters, pyroxanthrine, oxyphenic acid, dumasine, &c. To these must be added the influence of certain nitrogenized bodies, and we can understand how all these compounds, successively formed under the most favorable circumstances for acting on one another, since they are in the nascent state, and exposed to a high temperature, may give rise to the formation of a great variety of very different compounds which will be set free either in that state of a permanent gas, or a condensable vapor, and leave fixed carbon as a residue. The same takes place whether wood, coal, bituminous schists, boghead coal, asphalte, peat, resin, oils or animal matters be distilled; but it is evident that the original composition of the material submitted to dry distillation must powerfully influence the nature and composition of the products.

* Abridged from the *Moniteur Scientifique*, t. ii., liv. 86.

In those which, like wood, are rich in oxygen and poor in nitrogen, the pyrogenous products contain much acetic acid and but little ammonia, and consequently have an acid reaction; on the contrary the matters containing much nitrogen, and but little oxygen, like coal and animal matters, give rise to the formation of much ammonia, and the products have an alkaline reaction.

We intend in this article to confine our attention to the products obtained by the distillation and rectification of the coal tar from gas works. Considerable differences are noticed in the composition of the tar procured from different qualities of coal and schists, according to the rapidity with which the distillation has been conducted. Some tars, for instance, contain but little benzole and much naphthaline; boghead tar is rich in paraffine; others contain a preponderating quantity of phenol and benzole.

Table of the Products obtained by the Distillation and Rectification of Coal Tar.

Solid Products	Liquid Products.			Gaseous Products.
	Acids.	Neutral.	Bases.	
Carbon.	Rosolic.	Water.	Ammonia.	Hydrogen.
Naphthaline.	Brunolic.	Essence of tar.	Methylamine.	Carburetted hydrogen.
Paranaphthaline, or	Phenic, or Phenol.	Light oil of tar.	Ethylamine.	Bicarburetted hydrogen.
Anthraceine.	Acetic.	Heavy oil of tar.	Aniline.	Various hydrocarbides.
Paraffine.	Butyric.	Benzole.	Quinoline.	Carbonic oxide.
Chrysene.		Toluole.	Picoline.	Sulphide of carbon.
Pyrene.		Cumole.	Toluidine.	Carbonic acid.
		Cymole.	Lutidine.	Hydrosulphuric acid.
		Propyle.	Cumidine.	Hydrocyanic acid.
		Butyle.	Pyrrhol.	
		Amyle.	Pætinine.	
		Caproyle.		
		Hexylene.		
		Heptylene.		

Whatever may be the composition of the different kinds of tar, they are all submitted to distillation in order to isolate the principles capable of industrial application. But first of all it is necessary to separate the tar, as far as possible, from the ammoniacal liquor which is found with it. For this purpose it is heated some hours to 80° or 100° C. by which it is rendered more liquid, and then the water separates more easily. It is then allowed to cool very slowly, and the water is drawn off by a tap placed at the lower part of the boiler. A certain quantity of tar obstinately retains the water, constituting a buttery matter, which may be allowed to run away with the water, to be added afterwards to another quantity of tar, to be dehydrated by a fresh operation.

Experience seems to have demonstrated that the most simple process, that is to say, distillation over a naked fire at the ordinary pressure, is still the most practicable and advantageous. As the volatile products have but little latent heat, the height of the still should be somewhat less than the diameter; for the same reason the head must be carefully protected from cold, and it is well to furnish the inside with a circular gutter, in which the products condensed in the head may be collected and run into the refrigerator. By this means the

products are prevented from flowing back into the boiling tar and being decomposed by coming in contact with the sides of the still, which, especially towards the end of the operation, become very hot.

In condensing the vapors it is necessary to observe certain precautions. At the beginning of the operation, when the lighter and more volatile oils are passing, the worm must be well cooled to make quite sure of the condensation. Later, when the heavier and less volatile products are coming over, the water in the refrigerator may be allowed to get heated to 30° or 40°, and at last when the matters capable of solidifying, such as naphthaline and paraffine, pass, the temperature of the refrigerator should never be under 40°, and it may be allowed without inconvenience to rise to 60° or 70°. At this temperature the products condense perfectly, but remain liquid and run with ease. If the refrigerator were kept quite cold during the whole process, it might happen towards the end that the condensing tube would become blocked up by the solidified products, and a dangerous explosion might ensue.

At the beginning of the distillation the tar should not be allowed to boil too fast. Some distillers at this period pass a current of steam at 110° or 120° through the tar, to assist the disengagement of the more volatile oils. These in condensing form a limpid very fluid liquid, having the density ·780, which gradually rises to ·850; the mean density of all the products united is about ·830. It is this which constitutes the benzine of commerce. It contains a great variety of compounds whose boiling points range from 60° to 200°. They belong principally to the following series:—Cn Hn *e.g.* Amylene $C_5 H_5$; Hexylene (Oleene, Caproylene), $C_6 H_6$; Heptylene (Oenenthylene), $C_7 H_7$, &c. Cn Hn + 2 *e.g.* Propyle $C_{12} H_{14}$; Butyle, $C_{16} H_{18}$; Amyle, $C_{20} H_{22}$, &c. Cn Hn — 6 *e.g.* Benzine, $C_{12} H_6$, &c.

When the density of the products exceeds 850°, the current of steam is stopped and the heat is increased. As soon as the temperature of the tar has risen to 200°—220°, the distillation recommences, and the oil condensed is found to have the sp. gr. ·860—·900, the mean being from ·880 to ·885. This product constitutes the heavy oil of tar, and contains phenol, creosote, and aniline.

Lastly, the ultimate products of the distillation, which on cooling become a buttery mass (or crystalline, if they contain much naphthaline), are set aside for the preparation of paraffine. They are placed in vats, which are cooled, in order that the solid matters may separate by crystallization.

According to Payen, 2000 parts of rough oil or tar obtained by the distillation of boghead coal furnish on rectification:

1208 parts	light oil, density,	·825
200 "	heavy oil, "	·860
400 "	pitch.	

The loss of 200 parts represents the gases, and the vapors and oils which have escaped. 2900 parts of tar from gas works using boghead coal, distilled in a similar manner, yielded:

Water, slightly ammoniacal, . .		168 parts.
Light hydrocarbons, mean density .	·820	480 "
Heavy " " . .	·863	883 "
Fatty pitch, solid when cold, liquid at 150°		1195 "
Loss six per cent., . . .		174 "
		2900 "

(To be Continued.)

For the Journal of the Franklin Institute.

Strength of Cast Iron and Wrought Iron Pillars: A series of Tables deduced from several of Mr. Eaton Hodgkinson's Formulæ, showing the Breaking Weight and Safe Weight of Cast Iron and Wrought Iron Uniform Cylindrical Pillars. By Wm. Bryson, Civ. Eng.

(Continued from page 104.)

Table showing the breaking weight of hollow cylindrical pillars for different qualities of cast iron, both ends being flat and firmly fixed.

The formulæ for the breaking weight by which the following table for hollow pillars, and a preceding similar one for solid pillars, were calculated, are as under:

For the solid pillars,

$$W = m \times \frac{D^{3.55}}{L^{1.7}}.$$

For the hollow pillars,

$$W = m \times \frac{D^{3.55} - d^{3.55}}{L^{1.7}}.$$

m representing a weight varying from 78,400 lbs. to 134,400 lbs., the higher ones being used as examples only.

The co-efficients given by Mr. Hodgkinson are of course not applicable for the strength of all cast iron, therefore the weight must vary according to the strength of the material.

Height of Pillar in feet.	Number of diams. contained in the length or height.	External diameter in inches.	Internal diameter in inches.	Co-efficients for the strength, in lbs.					
				78,400	89,600	100,800	112,000	123,200	134,400
				Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
8	48	2	1	10·93	12·49	14·05	15·61	17·17	18·74
10	60	2	1	7·48	8·55	9·61	10·68	11·75	12·82
10	40	3	2	26·32	30·08	33·84	37·60	41·36	45·12
12½	50	3	2	18·01	20·58	23·15	25·73	28·30	30·87
12½	37½	4	3	41·95	47·94	53·93	59·92	65·92	71·91
15	45	4	3	30·77	35·16	39·56	43·95	48·35	52·74
15½	37 1-5	5	4	54·94	62·79	70·64	78·49	86·33	94·18
17	40 4-5	5	4	46·95	53·66	60·37	67·08	73·79	80·50
17½	35	6	5	74·37	84·99	95·62	106·24	116·87	127·49
20	40	6	5	59·26	67·73	76·14	84·66	93·13	101·60

Hollow Cylindrical Pillars for different qualities of Cast Iron, Both Ends being Flat and Firmly Fixed.

Height of Pillar in feet.	Number of diams. contained in the length or height.	External diameter in inches.	Internal diameter in inches.	Value of b in tons from formula, $b = 44{\cdot}34 \frac{D^{3.55} - d^{3.55}}{L^{1.7}}$.	Value of c, in tons.	Breaking weight in tons from formula, $W = \frac{bc}{b + \frac{3}{4}c}$.
15	30	6	5	122·45	381·86	114·36
15	30	6	5	122·45	423·33	117·82
15	30	6	5	122·45	477·32	121·65
				$b = 40{\cdot}00 \frac{D^{3.55} - d^{3.55}}{L^{1.7}}$.		
15	30	6	5	110·46	381·86	106·28
				$b = 50{\cdot}00 \frac{D^{3.55} - d^{3.55}}{L^{1.7}}$.		
15	30	6	5	138·08	477·32	132·86
				$b = 42{\cdot}347 \frac{D^{3.5} - d^{3.5}}{L^{1.63}}$.		
15	30	6	5	127·93	381·86	117·90
15	30	6	5	127·93	423·33	121·58
15	30	6	5	127·93	477·32	125·66
				$b = 46{\cdot}65 \frac{D^{3.55} - d^{3.55}}{L^{1.7}}$.		
15	30	6	5	128·83	381·86	118·47
15	30	6	5	128·83	423·33	122·19
15	30	6	5	128·83	477·32	126·31
				$b = 35{\cdot}00 \frac{D^{3.55} - d^{3.55}}{L^{1.7}}$.		
15	30	6	5	96·65	334·08	92·99

Mr. Hodgkinson found that the weight which would crush the pillars if they were very short, would vary as 5 to 9 nearly, and for long flexible pillars he found the weight varied from 49·94 tons, in the strongest iron he tried, to 33·60 tons in the weakest. Therefore, if we take the case of a hollow cylindrical pillar, of 6 inches external diameter and 5 inches internal diameter, beginning at 10 diameters or 5 feet high, the co-efficient for the strength will be 16·91 tons, for 6 feet high 20·88 tons, for 7 feet high 24·56 tons, for 8 feet high 27·84 tons, and so on, increasing till we arrive at 44·34 tons, or a trifle above 16 feet or 32 diameters. And in the case of a solid pillar of the same height and 6 inches diameter, the co-efficient for the strength will be 22·69 tons, increasing in a similar manner as in the above, till we arrive at 44·16 tons, or about 12½ feet or 25 diameters.

At page 309, vol. xli, of this Journal, I remarked that the breaking weight of pillars is not critically correct for pillars with flat ends whose height is only 30 diameters; I should there have expressed it as applying only to hollow ones, as the nearer we approach to a solid the farther we recede below 30 diameters, approaching nearer and nearer to 25 diameters, as in the solid pillars with flat ends, as will be seen by inspection of the following table for a hollow pillar, 15 feet high, and 6 inches external diameter. It is also made plain by this table, that a hollow pillar, 15 feet high, 6 inches external diameter, and whose sectional thickness is 2 inches, will support very nearly the same weight as a solid one of the same height and 6 inches diameter, with a saving in the weight of metal of 147·41 lbs.; that is, that 1179·37 lbs. will support as a hollow cylinder nearly as great a weight as a solid one containing 1326·78 lbs.; the safe weight of the former being 62·94 tons, and that of the latter 63·98 tons.

Table referred to in the above.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	External diameter in inches.	Internal diameter in inches.	Calculated weight of metal contained in pillar in lbs.	Value of b in tons from formula, $b = 44{\cdot}34 \frac{D^{3{\cdot}55} - d^{3{\cdot}55}}{L^{1{\cdot}7}}$.	Value of c, in tons.	Value of Y in tons from formula, $Y = \frac{bc}{b + \frac{4}{3}c}$.	Breaking weight in tons.
15	30	6	5	405·40	122 45	423·33	117·82	117·82
"	"	6	4½	578·94	164·42	606·23	161·00	161·00
"	"	6	4	737·10	196 04	769 69	195·12	195·12
"	"	6	3½	875·31	219 04	914 00	221·33	219·04
"	"	6	3	995·10	235 03	1039 08	240·76	235 03
"	"	6	2	1179·37	251·76	1231·50	263·77	251·76
"	"	6		1326·78				

Breaking weight of solid pillar in tons from formula $w = 44{\cdot}16 \frac{D^{3{\cdot}55}}{L^{1{\cdot}7}}$, 255·92.

The following table will show a few hollow pillars of different dimensions having a corresponding breaking weight as the pillar referred to above; also, the safe weight of each, and their weight of metal.

Length or height of Pillar in feet.	External diameter in inches.	Internal diameter in inches.	Weight of metal.	Breaking weight in tons.	Safe weight in tons.
10	6	4½	385·96	253 86	63·46
14	7	5½	643·24	250 23	62·55
18	8	6½	961·93	253·67	63·41
22½	9	7½	1368 26	253·79	63 44
27	10	8½	1840 94	254·44	63·61
12	6	4	589·68	255·29	63·82
16½	7	5	972 98	254·39	63·59
21¼	8	6	1461·93	252·54	63·13

I shall not in this series give any further tables for cast iron pillars with rounded ends, conceiving it sufficient for all practical purposes to assume one-ninth or one-tenth of the breaking weight of pillars with flat ends as a correct approximation for the safe weight if irregularly fixed, imperfectly set, or not truly perpendicular.

At page 307, vol. xli, I gave a table for pillars whose heights were less than 31 diameters with rounded ends, and, as I have omitted similar pillars with flat ends of the same dimensions, that should have preceded those with rounded ends, I introduce the following table to supply the deficiency.

Hollow Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	External diameter in inches.	Internal diameter in inches.	Calculated weight of metal contained in the Pillar, in lbs.	Calculated breaking weight in tons from formulæ, $b = 44{\cdot}34\,\frac{D^{3{\cdot}55} - d^{3{\cdot}55}}{l^{1{\cdot}7}}$ $\quad Y = \frac{be}{b + \frac{2}{3}e}$.	Safe weight in tons.	Safe weight if irregularly fixed, in tons.
8	24	4	2	235 87	147·30	36·82	14·73
9½	28 1-2	"	"	280·09	119·65	29·91	11 96
10	30	"	"	294 84	111·01	27·75	11·10
8	19 1-5	5	3	314 49	255 60	63 90	25 56
10	24	"	"	393 12	201·29	50·32	20·12
12	28 4-5	"	"	471·74	161·74	40·43	16·17
8	16	6	4	393·12	382·66	95·66	38·26
10	20	"	"	491·40	310 61	77·65	31·06
12	24	"	"	589·68	255·29	63 82	25 52
14	28	"	"	687·96	212·69	53·17	21·26
15	30	"	"	737·10	195 12	48·78	19·51
10	17 1-7	7	5	589·69	435·06	108 76	43 50
12	20 4-7	"	"	707·62	364·93	91 23	36·49
14	24	"	"	825·56	308·93	77·23	30·89
15	25 5-7	"	"	884·53	285·31	71·32	28·53
16	27 3-7	"	"	943 50	264·14	66·03	26 41
16½	28 2-7	"	"	972·98	254·39	63·59	25·43
12	18	8	6	825·56	487·28	121·82	48·72
14	21	"	"	963·15	418·58	104·64	41·85
15	22 1-2	"	"	1031·95	388·98	97·24	38 89
16	24	"	"	1100·75	362·14	90·53	36 21
18	27	"	"	1238 34	315·68	78 92	31·56
20	30	"	"	1375·94	277·22	69·30	27·72
14	16 4-5	10	8	1238·34	668·65	167·16	66·86
15	18	"	"	1326 79	628·21	157 05	62 81
16	19 1-5	"	"	1415·24	590·77	147·69	59 07
18	21 3-5	"	"	1592·15	524·13	131·03	52·41
20	24	"	"	1769·06	467·15	116·78	46·71
15	15	12	10	1621·63	898·08	224·52	89·80
16	16	"	"	1729·74	851·69	212·92	85·16
18	18	"	"	1945·96	767·17	191·79	76·71
20	20	"	"	2162 18	692·82	173·20	69·28
22	22	"	"	2378 39	627·60	156·90	62·76
25	25	"	"	2702·72	544·44	136·11	54·44
30	30	"	"	3243·27	436·76	109·19	43·67

Mr. Henry Law informs us that the following formula is Mr. Hodg-

kinson's for the strength of a hollow cylindrical column of wrought iron with both ends flat, when the height of the column is not less than 30 times its diameter:

$$w = 77{\cdot}2\,\frac{D^{3.6} - d^{3.6}}{L^{1.7}};$$

and Mr. Jos. W. Sprague in an article advocating his wrought iron bridge truss, says that "Hodgkinson's formula for the value of w in tons, is

$$w = 133{\cdot}75\,\frac{D^{3.55} - d^{3.55}}{L^2},$$

when the length of the column exceeds thirty times its diameter."

Up to the present I have not been able to discover that either of the above formulæ has emanated from Mr. Hodgkinson; but, as an example, I give below the result of my calculations deduced from each of them.

Table comparing the Strength of Hollow Cylindrical Pillars of Wrought Iron, by the formulæ above referred to.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	External diameter in inches.	Internal diameter in inches.	Calculated breaking weight in tons from formula, $w = 77{\cdot}2\,\frac{D^{3.6} - d^{3.6}}{L^{1.7}}$.	Calculated breaking weight in tons from formula, $w = 133{\cdot}75\cdot\frac{D^{3.55} - d^{3.55}}{L^2}$.
17½	35	6	5	181·20	120·42
20	40	"	"	144·40	92·20
20	40	"	5½	80·68	51·42
17½	35	"	"	101·25	67·16

There are so many considerations requisite, and all of them likely to lead to complicated results, that I shall make no attempt to form a table for the strength of hollow cylindrical pillars of wrought iron.

Tables showing the calculated breaking weight and safe weight of uniform solid cylindrical pillars of wrought iron, and the calculated weight of metal contained in each pillar.

Solid Uniform Cylindrical Pillars of Wrought Iron, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diams. contained in the length or height.	Diameter in inches.	Calculated weight of metal contained in the Pillar, in lbs.	Calculated breaking weight in tons from formula, $w = 133{\cdot}75\,\frac{D^{3.55}}{L^2}$.	Calculated breaking weight in tons from formula, $T = \frac{bc}{b + \frac{1}{4}c}$.	Safe weight in tons.	Safe weight if irregularly fixed, in tons.
5	30	2	53·07		54·14	13·53	5·41
6	36	"	63·68	43·51		10·87	4·35
7	42	"	74·29	31·97		7·99	3·19
8	48	"	84·91	24·47		6·11	2·44
9	54	"	95·52	19·34		4·83	1·93

Solid Uniform Cylindrical Pillars of Wrought Iron, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	Diameter in inches.	Calculated weight of metal contained in the Pillar in lbs.	Calculated breaking weight in tons from formula, $W = 133{\cdot}75 \frac{D^{3{\cdot}55}}{l^2}$.	Calculated breaking weight in tons from formula, $Y = \frac{bc}{b + \frac{1}{4}c}$.	Safe weight in tons.	Safe weight if irregularly fixed, in tons.
10	60	2	106·14	15·66		3·91	1·56
11	66	"	116·75	12·94		3·23	1·29
12	72	"	127·36	10·87		2·71	1·08
13	78	"	137·98	9·26		2·31	0·92
14	84	"	148·59	7·99		1·99	0·79
15	90	"	159·21	6·96		1·74	0·69
16	96	"	169·82	6·11		1·52	0·61
17	102	"	180·48	5·42		1·35	0·54
18	108	"	191·05	4·83		1·20	0·48
19	114	"	201·66	4·33		1·08	0·43
20	120	"	212·28	3·91		0·97	0·39
5	24	2½	82·92		104·39	26·09	10·43
6	28·8	"	99·51		83·58	20·89	8·35
7	33·6	"	116·09	70·59		17·64	7·05
8	38·4	"	132·68	54·04		13·51	5·40
9	43·2	"	149·26	42·70		10·67	4·27
10	48	"	165·85	34·59		8·64	3·45
11	52·8	"	182·43	28·58		7·14	2·85
12	57·6	"	199·02	24·02		6·00	2·40
13	62·4	"	215·60	20·46		5·11	2·04
14	67·2	"	232·19	17·64		4·41	1·76
15	72	"	248·77	15·37		3·84	1·53
16	76·8	"	265·36	13·51		3·37	1·35
17	81·6	"	281·94	11·96		2·99	1·19
18	86·4	"	298·53	10·67		2·66	1·06
19	91·2	"	315·11	9·58		2·39	0·95
20	96	"	331·70	8·64		2·16	0·86
5	20	3	119·42		174·67	43·66	17·46
6	24	"	140·30		143·40	35·85	14·34
7	28	"	167·18		118·35	29·58	11·83
8	32	"	191·07	98·49		24·62	9·84
9	36	"	214·95	81·44		20·36	8·14
10	40	"	238·84	66·07		16·51	6·60
11	44	"	262·72	54·60		13·65	5·46
12	48	"	286·60	45·88		11·47	4·58
13	52	"	310·49	39·09		9·77	3·90
14	56	"	334·37	33·71		8·42	3·37
15	60	"	358·26	29·36		7·34	2·93
16	64	"	382·14	25·80		6·45	2·58
17	68	"	406·02	22·86		5·71	2·28
18	72	"	429·91	20·39		5·09	2·03
19	76	"	453·79	18·30		4·57	1·83
20	80	"	477·68	16·51		4·12	1·65
5	17·142	3½	162·55		265·75	66·43	26·57
6	20·571	"	195·06		222·95	55·73	22·29
7	24	"	227·57		187·30	46·82	18·73
8	27·428	"	260·08		158·12	39·53	15·81
9	30·857	"	292·59		134·40	33·60	13·44

Solid Uniform Cylindrical Pillars of Wrought Iron, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	Diameter in inches.	Calculated weight of metal contained in the Pillar, in lbs.	Calculated breaking weight in tons from formula, $W = 133{\cdot}75\frac{D^{3{\cdot}55}}{l^2}$.	Calculated breaking weight in tons from formula, $Y = \frac{bc}{b+\frac{1}{2}c}$.	Safe weight in tons.	Safe weight if irregularly fixed, in tons.
10	34·285	3½	325·10	114·21		28·55	11·42
11	37·714	"	357·61	94·39		23·59	9·43
12	41·142	"	390·12	79·31		19·82	7·93
13	44·571	"	422·69	67·58		16·89	6·75
14	48	"	455·14	58·27		14·56	5·82
15	51·428	"	487·65	50·76		12·69	5·07
16	54·857	"	520·16	44·61		11·15	4·46
17	58·284	"	552·67	39·52		9·88	3·95
18	61·714	"	585·18	35·25		8·81	3·52
19	65·142	"	617·69	31·63		7·90	3·16
20	68·571	"	650·20	28·55		7·13	2·85
5	15	4	212·30		377·93	94·48	37·79
6	18	"	254·76		323·04	80·76	32·30
7	21	"	297·22		275·71	68·92	27·57
8	24	"	339·68		235·84	58·96	23·58
9	27	"	382·14		202·63	50·65	20·26
10	30	"	424·60		175·08	43·77	17·50
11	33	"	467·06	151·64		37·94	15·16
12	36	"	509·52	127·42		31·85	12·74
13	39	"	551·98	108·57		27·14	10·85
14	42	"	594·44	93·61		23·40	9·36
15	45	"	636·90	81·55		20·38	8·15
16	48	"	679·36	71·67		17·91	7·16
17	51	"	721·82	63·49		15·87	6·34
18	54	"	764·28	56·63		14·15	5·66
19	57	"	806·74	50·82		12·70	5·08
20	60	"	849·20	45·87		11·46	4·58
5	13·333	4½	268·70		511·27	127·81	51·12
6	16	"	322·44		444·07	111·01	44·40
7	18·666	"	376·18		384·36	96·09	38·43
8	21·333	"	429·92		332·74	83·18	33·27
9	24	"	483·66		288·78	72·19	28·87
10	26·666	"	537·40		251·63	62·90	25·16
11	29·333	"	591·14		220·30	55·07	22·03
12	32	"	644·88	193·56		48·39	19·35
13	34·666	"	698·62	164·93		41·23	16·49
14	37·333	"	752·36	142·21		35·55	14·22
15	40	"	806·10	123·88		30·97	12·38
16	42·666	"	859·84	108·88		27·22	10·88
17	45·333	"	913·58	96·44		24·11	9·64
18	48	"	967·32	86·02		21·50	8·60
19	50·666	"	1021·06	77·21		19·30	7·72
20	53·333	"	1074·80	69·68		17·42	6·96
5	12	5	331·75		665·71	166·42	66·57
6	14·4	"	398·10		586·24	146·56	58·62
7	16·8	"	464·45		513·76	128·44	51·37
8	19·2	"	530·80		449·62	112·40	44·96
9	21·6	"	597·15		393·89	98·47	39·38

Solid Uniform Cylindrical Pillars of Wrought Iron, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	Diameter in inches.	Calculated weight of metal contained in the Pillar, in lbs.	Calculated breaking weight in tons from formula, $w = 133{\cdot}75\,\frac{D^{3{\cdot}55}}{l^2}$.	Calculated breaking weight in tons from formula, $r = \frac{b\,c}{b + \frac{1}{4}c}$.	Safe weight in tons.	Safe weight if irregularly fixed, in tons.
10	24	5	663·50		345·96	86·49	34·59
11	26·4	"	729·85		304·95	76·23	30·49
12	28·8	"	796·20		269·90	67·47	26·99
13	31·2	"	862·55	239·74		59·93	23·97
14	33·6	"	928·90	206·71		51·67	20·67
15	36	"	995·25	180·07		45·01	18·00
16	38·4	"	1061·60	158·26		39·56	15·82
17	40·8	"	1127·95	140·19		35·04	14·01
18	43·2	"	1194·30	125·05		31·26	12·50
19	45·6	"	1260·65	112·23		28·05	11·22
20	48	"	1327·00	101·29		25·32	10·12
5	10	6	477·70		1037·28	259·32	103·72
6	12	"	573·24		934·01	233·50	93·40
7	14	"	668·78		835·68	208·92	83·56
8	16	"	764·32		745·16	186·29	74·51
9	18	"	859·86		663·69	165·92	66·36
10	20	"	955·40		591·42	147·85	59·14
11	22	"	1050·94		527·89	131·97	52·78
12	24	"	1146·48		472·31	118·07	47·23
13	26	"	1242·02		423·82	105·95	42·38
14	28	"	1337·56		381·51	95·37	38·15
15	30	"	1433·10	343·98		85·99	34·39
16	32	"	1528·64	302·33		75·58	30·23
17	34	"	1624·18	267·81		66·95	26·78
18	36	"	1719·72	238·88		59·72	23·88
19	38	"	1815·26	214·39		53·59	21·43
20	40	"	1910·80	193·52		48·38	19·35

Hollow Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	External diameter in inches.	Internal diameter in inches.	Calculated weight of metal contained in the Pillar in lbs.	Calculated breaking weight in tons from formulæ, $b = 44{\cdot}34\,\frac{D^{3{\cdot}55} - d^{3{\cdot}55}}{l^{1{\cdot}7}}$, $r = \frac{b\,c}{b + \frac{1}{4}c}$.	Safe weight in tons.	Safe weight if irregularly fixed, in tons.
8	8	12	10½	663·40	1003·66	250·91	100·36
9	9	"	"	746·32	955·46	238·86	95·54
10	10	"	"	829·25	908·30	227·07	90·83
11	11	"	"	912·17	862·65	215·66	86·26
12	12	"	"	995·10	818·78	204·69	81·87
13	13	"	"	1078·02	776·89	194·22	77·68
14	14	"	"	1160·95	737·10	184·27	73·71
15	15	"	"	1243·87	699·44	174·86	69·94
16	16	"	"	1326·80	663·89	165·97	66·38

Hollow Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Number of diameters contained in the length or height.	External diameter in inches.	Internal diameter in inches.	Calculated weight of metal contained in the Pillar, in lbs.	Calculated breaking weight in tons from formulæ, $b = 44{\cdot}34\,\frac{D^{3{\cdot}55} - d^{3{\cdot}55}}{L^{1{\cdot}7}}$ $Y = \frac{bc}{b + \frac{3}{4}c}$.	Safe weight in tons.	Safe weight if irregularly fixed, in tons.
17	17	12	10½	1409·72	630·42	157·60	63·04
18	18	"	"	1492·65	598·96	149·74	59 89
19	19	"	"	1575·57	569·41	142·35	56·94
20	20	"	"	1658 50	541·68	135·42	54·16
21	21	"	"	1741 42	515 67	128·91	51·56
22	22	"	"	1824 35	497·67	124·41	49·76
23	23	"	"	1907·27	468·42	117·10	46·84
24	24	"	"	1990·20	446·98	111·74	44·69
25	25	"	"	2073·12	426·86	106·71	42 68
26	26	"	"	2156·05	407·97	101·99	40·79
27	27	"	"	2238·97	390·28	97·57	39·02
28	28	"	"	2321·90	373·56	93·39	37·35
29	29	"	"	2404·82	357·88	89·47	35·78
30	30	"	"	2487·75	343·13	85·78	34·31
8	7 5-13	13	11½	722·36	1124·08	281·02	112·40
9	8 4-13	"	"	812·66	1075·17	268 79	107·51
10	9 3-13	"	"	902·96	1026·87	256·71	102·68
11	10 2-13	"	"	993 25	979·67	244·91	97·96
12	11 1-13	"	"	1083·55	933·92	233·48	93·39
13	12	"	"	1173·84	889 86	222·46	88·98
14	12 12-13	"	"	1264·14	847·66	211·91	84·76
15	13 11-13	"	"	1354·44	807·40	201·85	80·74
16	14 10-13	"	"	1444·73	769·13	192·28	76·91
17	15 9-13	"	"	1535 03	732 83	183·20	73·28
18	16 8-13	"	"	1625·32	698·50	174·62	69·85
19	17 7-13	"	"	1715 62	666·04	166·51	66·60
20	18 6-13	"	"	1805·92	635·40	158·85	63·54
21	19 5-13	"	"	1896·21	606·52	151·63	60·65
22	20 4-13	"	"	1986 51	579·29	144·82	57·92
23	21 3-13	"	"	2076·80	553·63	138·40	55 36
24	22 2-13	"	"	2167·10	529·46	132·36	52·94
25	23 1-13	"	"	2257·40	506·69	126·67	50·66
26	24	"	"	2347 69	485·21	121·30	48·52
27	24 12-13	"	"	2437 99	464·97	116·24	46·49
28	25 11-13	"	"	2528·28	445·88	111·47	44·58
29	26 10-13	"	"	2618·58	427·87	106·96	42·78
30	27 9-13	"	"	2708·88	410·87	102·71	41·08

(To be Continued.)

Magnetic Phenomenon.

From the Lond. Ed. and Dub. Phil. Mag., October, 1860.

M. Ruhmkorff has the following notice in the *Comptes-Rendus*, vol. l, p. 166:—"If a stay (*bride*) of soft iron be pressed against one of the poles of an artificial magnet, the soft iron is observed to become hard, and it is more difficult to file. If the stay be removed, it loses its hardness and resumes all the properties of soft iron."

On White Gunpowder. By M. Pohl.

From the Lond. Edin. and Dub. Phil. Mag., July, 1861.

Pohl has communicated* a research on the white gunpowder invented by Augendre, which consists of prussiate of potash, white sugar, and chlorate of potash. Pohl finds that the following mixture gave a very good burning powder:—

Prussiate of potash,	28 parts.
Sugar,	23 "
Chlorate of potash,	49 "
	100

which is very nearly in the relation

$$K^2Cfy, 3HO + C^{12}H^{11}O^{11} + 3KO\,Cl\,O^5.$$

Of the products formed by the combustion of this powder, it would be difficult to state any thing with accuracy without very numerous analyses, and they would differ according as the combustion was free or in a closed space, and whether it was slow or rapid. Assuming that the possible products of decomposition of the ferrocyanide are nitrogen, cyanide of potassium, and a carbide of iron of the formula FeC^2, the decomposition might be represented in the following manner:—

$$K^2Fe\,Cy^3 + C^{12}H^{11}O^{11} + 3(KO\,Cl\,O^5) = 2K\,Cy + 3K\,Cl + Fe\,C^2 + N + 6CO + 6CO^2 + 14HO;$$

according to which 100 parts of the powder would yield 52·56 parts of non-volatile, and 47·44 of gaseous substances.

The decomposition may take place in conformity with other reactions, but from a preliminary investigation this appears the most probable.

In accordance with this, 100 parts of the powder would yield—

Nitrogen,	1·86
Carbonic oxide,	11·19
Carbonic acid,	17·59
Water,	16·79
	47·43

and

Cyanide of potassium,	17·38
Chloride of potassium,	29·84
Carbide of iron,	5·33
	52·55

hence, reduced to volumes at 0° and 760 millims., 100 parts would yield—

Nitrogen,	1927 cub. centims.
Carbonic oxide,	8943 "
Carbonic acid,	8943 "
Aqueous vapor,	20867 "
	40680 "

* *Sitzungsberichte der Wiener Akademie*, vol. xli.

Pohl calculates from this that the quantity of heat furnished by the combustion of this substance would be equal to 506·3 thermal units. The temperature of the combustion is obtained by dividing the number of thermal units by the sum of the specific heats of the products of combustion, which amounts to 0·2636; and this gives 1920° C. as the temperature. From Bunsen and Schischkoff's research,* it appears that the heating effect of ordinary gunpowder is 619·5 thermal units, and that the temperature of its free combustion is 2993° C. It furnishes in 100 parts, 68·06 of solid residue, and 31·38 of gaseous products, corresponding to 19,310 cubic centims. From these data, the relation between the two substances is—

	Black powder.		White powder.
The quantity of gas,	1	:	2·107
The temperature of flame,	1	:	0·641
The residues,	1	:	0·77

But for the respective temperatures of combustion the reduced volumes of gas would be, for black powder, 231,411 cubic centims., and, for white powder 300,798 cubic centims., and hence the quantities of gas would be as 1 : 1·13.

In the combustion in a confined space, the temperature of the combustion would be altered, for there would be a great difference in the specific heat of the products of combustion. Hence, the volume of gas, when reduced to the normal temperature and pressure, would vary. For white gunpowder, Pohl calculates the temperature of combustion in a closed space at 2604° C., and the volume of gas furnished by 100 parts at 431,162 cubic centims. Under similar circumstances Bunsen and Schischkoff found that the temperature was 3340° C., and the volume of gas 258,420 cubic centims.

Hence, the relation between the products of combustion in confined space would be—

	Black powder.		White powder.
The temperature of the flames,	1	:	0·779
The volumes of gas,	1	:	1·669

As the action of an explosive powder principally depends on the volume of the gases formed, for equal weights the new white powder would produce 1·67 times the action of the other. But for equal volumes of the powder the ratio would be different. Pohl found that a vessel which held 102·542 grms. of white powder, held 132·355 grms. of ordinary black powder. Hence, the density of the new powder in reference to the other would be as 0·774 : 1, and the work performed by equal volumes would be as 1·292 : 1.

In order to produce the same effect on projectiles, in firing mines, &c., 60 parts by weight of the new, would be required for 100 parts of the old. The weights of the residues in the two cases are respectively 31·53 and 68 parts. Another advantage of the white powder is, that the temperature of the flame is much lower; a greater number of shots could be fired without heating the projectile too much. The new powder is more energetic in its action than the old, and in

*Phil. Mag., vol. xv, p. 489.

this respect stands nearest gun-cotton. It has the advantage over this substance of being cheaper and easier to prepare, and it can be kept for a long time without undergoing any change.

The new powder contains chlorate of potash; and this, in all substitutes for gunpowder of which it is a constituent, forms products of combustion at a high temperature, which attack the fire arms. If the decomposition of the white powder takes place in accordance with the equation already given, it is not easy to see why this evil is to be feared. It could be most simply decided by firing off a certain number of shots with a given weapon. Another advantage of the new powder is its difficult explosibility by pressure and percussion. Explosion is only produced by the heaviest blow of iron upon iron; it is not produced by the friction of wood upon metal, or between stones, &c. The new powder is also far easier of preparation than the old; and if the raw materials are at hand, a large quantity of it may be prepared in a few hours with no other apparatus than a stamping-mill and mixing tub.

Some Results of the Census of 1861.

From the London Builder, No. 958.

By the exertions made at the Census Office, we are enabled to obtain some idea of the population of England on the 8th of April last; for, although the returns recently made by the Registrar-General from the books of the 631 superintendent registrars of England have not yet been fairly tested at the Census Office, it is not apprehended that the alterations, which a careful revision of the original documents may render necessary, will be of importance sufficient to lessen the value of the figures as materials for whatever general inferences may fairly be drawn from them.

In first glancing at these figures, it is important to notice that the decennial rates of increase have declined since the ten years from 1811 to 1821, and have up to 1861 been steadily on the decrease, as will be seen by an examination of the following figures:—

	Population of England.	Increase.	Decennial Rate of Increase.
1801	9,156,171		
1811	10,454,529	1,298,358	14 per cent.
1821	12,172,644	1,718,135	16 "
1831	14,051,986	1,879,322	15 "
1841	16,035,198	1,983,212	14 "
1851	18,054,170	2,018,972	13 "
1861	20,223,746	2,169,576	12 "

The cause of this decrease in the decennial rate of the population is a matter which calls for very careful inquiry; we therefore look anxiously forward to those details of the Census returns which will

be likely to show the cause of a decline which is not to be attributed to increased death-rates; for it is certain that the average duration of human life, in the chief districts of both town and country, has, by means of sanitary and other improvements, been materially increased; nor is the decrease to be accounted for by the extent of the emigration from England; for the returns of the Emigration Commissioners show that, in the interval between March 31st, 1851, and April 8th, 1861, 2,249,355 emigrants sailed from the ports of the United Kingdom. But of this number, probably 194,522 were of foreign origin; leaving 2,054,823 emigrants from the population of the United Kingdom; of whom only about 640,210 were of English origin, 183,627 were of Scotch origin, and 1,230,986 were of Irish origin.

Notwithstanding the decline in the decennial rates, it is satisfactory to find that in the last ten years 2,169,576 have been added to the population of England;* and to compare our condition in this respect with that of about the middle of the last century, when it was the practice to subsidize foreign troops for the defence of the nation and for the preservation of order. From the Peace of Utrecht down to 1740, the numbers of the English people had actually declined; and in 1756, by a grant of the Parliament, a large body of Hanoverians and Hessians arrived on our shores.

From 1751 to 1772, after the passing of Lord Hardwick's Marriage Act, the increase of the population became more satisfactory. This is partly to be attributed to the improved habits of the people, the increase of well-constituted families, and the great increase of the industry of Great Britain.

The manufacture of iron by wood-charcoal in England rapidly declined; until at length, in the year 1740, the produce fell to 17,350 tons. Coal was tried, and, after that time, was successfully used for smelting; so that, in 1788, the produce was *seventy thousand tons;* in 1800, a *hundred and eighty thousand tons;* and in the year 1851, two millions five hundred thousand tons. Iron and steel tools have been placed in the hands of the workmen and laborers of the country, —arms in the hands of the army and navy.

After 1751, agriculture advanced rapidly. Lord Townsend introduced the turnip-culture from Germany, with important results. Many of the landed proprietors, instead of drowning their senses in drink, wasting their time in intrigues, or squandering their estates in gambling, devoted themselves to the encouragement of societies of agriculture: the farmers adopted new processes; the increased produce of the farms was improved in quality: marshes were drained; machinery introduced; the breeds of various domestic animals decidedly improved; and an impulse given to the cultivation of the finest part of agricultural science, which is intimately related to the science of population, and will in the end throw much light on its principles.

New roads were made and old ones improved; and canals for the transport of wood, coal, goods, and general produce, were commenced

* We have no returns yet for Scotland and Ireland.

by the enlightened spirit of Bridgewater, who, with the aid of Brindley's genius, triumphed over engineering difficulties which in those days were held insuperable. New machines were invented, and new employments brought into use.

Josiah Wedgwood, the potter, produced (1763) a new kind of earthenware; Paul or Wyatt first, and then Arkwright, the barber, invented a spinning-jenny in 1767; Hargreaves, a weaver, took out the patent for his spinning-jenny in 1770; and the mule was completed by Compton, also a weaver, in 1787. James Watt placed the force of steam at man's disposal. By other eminent men, a thousand different means have been produced, yielding in value millions sterling yearly, and so offering occupation and subsistence to the population; and, since 1830, the railroads, with steam and sailing vessels, have placed the population in direct and easy communication, not only with each other in Great Britain, but with the rest of the world.

The circumstances of our times disprove the theory of Malthus and the supporters of his ideas, for they show that, although the population has doubled in a period of about fifty-three years, employment is more plentiful, and the necessaries of life more easily to be obtained, than when the number of the people in the land was comparatively small.

The population of the metropolis in April, 1861, is given at 2,803,034, as against 2,362,236 in 1851: increase in ten years, 440,788; average per year, 44,078·8. And it may be useful here to give the increase of the population of the London district since 1801:—

	Population.	Increase in ten years.	Increase per year.
1801	958,863		
1811	1,138,815	179,922	17,995·2
1821	1,378,947	240,132	24,013·2
1831	1,654,994	276,047	27,604·7
1841	1,984,417	329,423	32,942·3
1851	2,362,236	377,819	37,781·9
1861	2,803,034	440,798	44,079·4

In the thirty-seven districts into which the area of the metropolis is divided, ten have decreased in population, viz:—

	1851.	1861.	Decrease.
St. Martin's-in-the-Fields,	24,640	22,636	2,004
St. James's, Westminster,	36,406	35,324	1,082
St. Giles's,	54,214	53,981	233
Strand,	44,417	42,956	1,461
Holborn,	46,621	44,861	1,760
East London,	44,406	40,673	3,733
West London,	28,833	27,144	1,688
London City,	55,932	45,550	10,382
Whitechapel,	79,759	78,963	796
St. Olave's, Southwark,	19,375	19,053	322

It will thus be seen that, during the last ten years, nearly one-fifth of the population of London City has been removed; that there is a marked decrease in the numbers in East London, West London, the Strand, and Holborn; the decrease in St. Giles's, Whitechapel, and St. Olave's, being small in comparison.

The following shows the increase of the other districts:—

	Population, 1851.	Population, 1861.	Increase.
Kensington,	120,004	186,463	66,459
Chelsea,	56,538	63,423	6,885
St. George's, Hanover-square,	73,230	87,747	14,517
Westminster,	65,609	67,676	2,067
Marylebone,	157,696	161,609	3,913
Hampstead,	11,986	19,104	7,118
Pancras,	166,956	198,882	31,296
Islington,	95,329	155,291	59,962
Hackney,	58,429	83,295	24,866
Clerkenwell,	64,778	65,632	854
St. Luke's,	54,055	56,697	2,942
Shoreditch,	109,257	129,339	20,082
Bethnal-green,	90,193	104,905	14,712
St. George's-in-the-East,	48,376	48,876	502
Stepney,	54,173	56,567	2,394
Mile-end Old Town,	56,602	73,064	16,462
Poplar,	47,162	79,182	32,020
St. Saviour's, Southwark,	35,731	36,026	295
Bermondsey,	48,128	58,355	10,227
St George's, Southwark,	51,824	55,509	3,685
Newington,	64,816	82,157	17,341
Lambeth,	139,325	162,008	22,683
Wandsworth,	50,764	71,489	16,822
Rotherhithe,	17,805	24,500	6,695
Greenwich,	99,365	127,662	28,297
Lewisham,	35,835	65,752	30,917

We thus see that the greatest increase of the London district has been—first in Kensington, second in Islington, third in Poplar, fourth in Pancras, fifth in Lewisham, sixth in Greenwich, seventh in Hackney and Hampstead. Then follow Lambeth, Shoreditch, Mile-end Old Town, Bethnal-green, &c., &c.

While this immense increase is going forward in the suburban neighborhoods, the old parts of London, as regards their population, have either decreased or have remained during the last ten years nearly stationary. In Clerkenwell, with a population of upwards of 65,000, there has been only an increase of 854; in Westminster, with a population of over 67,000, an increase of 2067; Marylebone, population of more than 161,000, an increase of 3913; St. Saviour's, Southwark, population upwards of 36,000, an increase only of 502. The peculiarities of the metropolitan population may be attributed to various causes, amongst which may be mentioned the conversion of the central parts of the City into places of business, the facilities afforded by omnibus, steam-packet, and railway conveyance, to and from the

suburbs; there is also the demolition of dwellings in some localities. To this important matter we will take an opportunity of carefully referring, too, as soon as we have the exact figures of the number of the inhabitants, and the number of the dwellings in each district.

Taking the whole of the metropolitan district, in 1851 the population was 2,362,236; the number of inhabited houses, 305,933. This gives an average of $7\frac{220}{305},\frac{705}{933}$ persons in each house. In April, 1861, the population was 2,803,034; the number of houses, 362,890. The average number of inhabitants of each house, $7\frac{264}{362},\frac{804}{890}$. We thus find that, upon the whole, in London there has been a very slight increase of overcrowding in dwellings.

From this we can form but little idea of the unwholesome overcrowding of certain localities. When, however, more details come to hand, we trust that, by the help of them and by some personal observation, we shall be able to throw some useful light upon the changing features of the metropolis.

In 1841, the average number of persons to each inhabited house throughout England and Wales was 5·4, instead of 7·4 in the London division.

During the ten years above referred to, 56,957 inhabited houses have been added to this monster city; this is at the rate of rather more than five thousand six hundred and ninety-five in each year. This is a vast amount of new work to be added to the houses which have been rebuilt or altered during this period.

The periodical taking of the census is a laborious and expensive affair, but the value of the result is great. On the last occasion, 31,000 enumerators were employed for the purpose of numbering the people. From a return made to Parliament by the Registrar-General in 1851, we learn that all the local expenses were paid out of the poor-rates in 1841; in 1851 the whole of the expenses were voted by Parliament. In 1841, the cost in England of taking the census of that year, exclusive of postage and printing, was at the rate of £5 9*s.* for every thousand of the population; taking the population of England in the above year at sixteen millions thirty-five thousand and over, this would come to about £87,388. In 1851, when the inquiry was greatly extended, the cost was £5 4*s.* for each thousand; the population then was eighteen millions and rather more than fifty-four thousand; the expense would, exclusive of Scotland and Ireland, be about £93,880.

Photo-Zincography.

From the Lond. Engineer, No. 284.

Colonel Sir Henry James, R. E., Director of the Ordnance Survey, has published the result of various experiments which he has made in photo-zincography, or the art of copying ancient manuscripts, or any outline engravings. Colonel James states that he has been assisted in his labors by Captain A. deC. Scott, R. E. The art is certainly a most useful and valuable one, for, by means of it, rare and important

documents or books may be copied and multiplied to any extent. Thus, a copy has been taken of that part of "Domesday Book" which relates to Cornwall, and the public are likely to reap the benefit of the invention, as a fac-simile of the most expensive books, manuscripts, or engravings, may be obtained at a very cheap rate. We observe, too, that Mr. Erle proposes to republish an early Saxon manuscript by the same means. Half a century ago or so, it was thought that Bewick's engravings could never be surpassed, although we need hardly say that the illustrated publications of the present day evince an almost magical improvement in the art. However, photo-zincography will enable the public to judge of Bewick's engravings, as a pamphlet has been published by Colonel James, containing a photo-zincographic copy of Bewick's "golden eagle," with the view not only of showing the style in which "Bewick's British Birds" were engraved, but also to enable a judgment to be formed of the perfection to which the photo-zincographic process has been brought. The pamphlet to which we allude gives the following description of photo-zincography:—By the term "photo-zincography" is meant, as the name implies, the art of producing a photographic fac-simile of any subject—such as a manuscript, a map, or line engraving, and transferring the photograph to zinc, thereby obtaining the power of multiplying copies in the same manner as is done from a drawing on a lithographic stone or on a zinc plate. The first part of the process concerns the production of a negative photograph on glass of the document of exactly the same size as the original. This is obtained by the ordinary wet collodion process, and too great care cannot be taken to obtain one as perfect as possible, as every defect will be transmitted through each step of the process till it affects the final result. As affecting success at this stage, the lens used should be as perfect as possible, and fully capable of projecting an image of the size required without sensible distortion. Lenses are used at the Ordnance Survey-office of various diameters, depending on the size of the document to be copied—the largest being 8 ins. in diameter, 41 ins. in principal focal length, and capable of producing negatives free from sensible distortion 16 ins. square, a stop 1 in. in diameter being placed 8 ins. in front of it. The distance from the lens to the ground-glass of the camera when adjusted so as to copy a subject in the same size, is 7 ft. 3 ins., and from the lens to the subject of course the same. The readiest means of adjusting the camera and lens in their proper position relatively to the object and to each other when it is required to produce a negative the same size, is to ascertain by actual measurement with a proper scale a lineal dimension of the subject (as its width or length), and so to regulate the distance of the lens from it, that when the image is focussed on the ground-glass it shall equal, in its corresponding dimension, that already read on the scale. This can easily be done by a system of repeated trial and correction of error. When the lens and camera are in adjustment, the glass plate is covered with the sensitive coating—exposed, developed, and fixed in the ordinary way; when fixed, it is immersed in a saturated solution of chloride of mercury (corrosive

sublimate). When well whitened by the action of the salt, it is removed, washed with water, and then with a solution of hydro-sulphate of ammonia, consisting of ten parts of water to one of hydro-sulphate of ammonia of commerce. In this manner the ground of the negative is rendered extremely dense, without affecting the clearness of the detail. When dried and varnished it is ready for use. We now come to the preparations of the sensitive paper. The quality of the paper used is a point of much importance. Various samples have been tried, but that which has been found best suited for the purpose is a semi-transparent kind, with a smooth surface, known by the name of engravers' tracing-paper. The next process is the coating of the whole surface of the print with an even and thin layer of a greasy ink, which is composed of the following ingredients:—Middle linseed-oil varnish, 4½ oz.; wax, 4 oz.; tallow, ½ oz.; Venice turpentine, ½ oz.; gum mastic, ¼ oz.; lamp black, 3½ oz. A portion of the above is dissolved in oil of turpentine, so as to make a solution of the consistency of thin cream, which is easily applied to the surface of the print with a brush. As soon as the lines are quite clear, the print is placed in a flat dish, and washed, first with warm, and finally with cold water. When dry, it is ready for transferring to zinc or stone. There are two methods of transferring to zinc, varying according to the quantity of ink on the photograph. If a very small quantity has been applied on account of the closeness of the subject, the print is transferred by the "anastatic" process.

For the Journal of the Franklin Institute.

Particulars of the Steamer Mississippi.

Hull built by Wm. H. Webb. Machinery by Morgan Iron Works, New York. Owners, New York and Savannah Steamship Co. Intended service, New York to Savannah, Georgia.

HULL.—Length on deck, 250 ft. Breadth of beam (molded), 38 ft. Depth of hold, 14 ft. 8 ins. Do., to spar deck, 22 ft. 6 ins. Frames—molded, 15 ins., sided, 16 ins.; apart at centres, 32 ins.; strapped with diagonal and double laid braces, 4½ × ¾ in. Depth of keel, 9 ins. Two bulkheads. Draft of water, fore and aft, 13 ft. 6 ins. Tonnage, 2070. Area of immersed section at load draft of 13 ft. 5 ins., 468 sq. ft. Displacement at load line, 2525 tons. Masts, two.

ENGINES.—Vertical beam. Diameter of cylinder, 80 ins. Length of stroke, 11 ft. Cut-off, one-half.

BOILERS.—Two—Return flue. Length of boilers, 30 ft. Breadth do., 13 ft. Height do., exclusive of steam chimney, 13 ft. Number of furnaces, five in each. Breadth do., 3 ft. 2 ins. Length of grate bars, 9 ft. Number of flues, above, 7 of 13¾ ins. and 7 of 14¾ ins.; below, 15 of 15 ins. Length do., above, 22 ft. 6 ins.; below, 15 ft. ½-in. Grate surface, 279 sq. ft. Heating surface, 6013 sq. ft. Diameter of smoke pipe, 6 ft. 6 ins. Height do., 36 ft.

PADDLE WHEELS.—Diameter overblades, 34 ft. Length of blades, 9 ft. 6 ins. Depth do., 24 ins. Number do., 28.

Date of trial, May, 1861. C. H. H.

For the Journal of the Franklin Institute.

Particulars of the Caloric Primera.

Hull built by S. Sneden & Co. Machinery by C. H. Delamater, New York. Owners, Pesant, Bros. & Co.

HULL.—Length on deck, 144 ft. Do. between perpendiculars, 135 ft. Breadth of beam (molded), 22 ft. Do., over guards, 34 ft. Depth of hold to spar deck, 9 ft. Length of engine room, 8 ft. Frame—shape, L, depth, 3 ins.; width of web, $\frac{3}{8}$ ins.; width of flanch, 3 ins.; thickness of plates, $\frac{3}{8}$ths to No. 2. Cross Floors—description, T, 9 ins. high, 5-16ths thick; every other frame, angle iron at top, 3-5 × 3-5 × 7-16ths. Rivets, $\frac{3}{8}$ths, single riveted. One independent caloric, fire and bilge pump. Two bulkheads. Stringer plates, fore and aft, 15 ins. wide by 5-16ths thick. Draft of water fore and aft, 6 ft. 3 ins. Tonnage, 284 tons. Area of immersed section at load draft of 6 ft. 3 ins., 132 sq. ft. Masts, two.—Rig, schooner.

ENGINES.—Double-acting, condensed pressure, caloric. Diameter of cylinder, 40 ins. Length of stroke, 2 ft. Weight of engines and propeller, 70,000 lbs. Number of furnaces, two.

PROPELLER.—Diameter of screw, 8 ft. Pitch do., 16 ft. Length of blades, 1 ft. 9 ins. Number do., four.

Date of trial, January, 1861. C. H. H.

For the Journal of the Franklin Institute.

Particulars of the Steamer North Carolina.

Machinery built by Novelty Iron Works, New York. Owners, H. B. Cromwell & Co. Intended service, New York to North Carolina.

HULL.—Length on deck, 172 ft. Do. load line, 166 ft. Breadth of beam, molded, 29 ft. Depth of hold to spar deck, 13 ft. Frames—sketch of shape, L; depth, 4 ins.; width of web, 3 ins.; width of flanches, 3 ins; 10 strakes of plates from keel to gunwale, $\frac{1}{2}$ in. thick. Cross floors—description, T, 14 ins. deep, angle iron, 3 × 4 ins. Diameter of rivets, $\frac{3}{4}$ in.; single riveted. One independent steam, fire, and bilge pump. 4 bulkheads. Length of engine room, 16 ft. 9 ins. Draft of water, forward, 9 ft.; aft, 10 ft. Tonnage, 613 tons. Area of immersed section at load draft of 11 ft. Masts, two. Rig, topsail schooner.

ENGINES.—Vertical direct. Diameter of cylinder, 42 ins. Length of stroke, 3 ft. 6 ins. Maximum pressure of steam, 30 lbs. Cut off, one-third. Maximum revolutions at above pressure, 60.

BOILER.—One.—Return tubular. Length of boiler, 15 ft. 3 ins. Breadth do., 12 ft. 4 inches. Height do., exclusive of steam chimney, 15 ft. 6 ins. Number of furnaces, three. Breadth do., 3 ft. 5 ins. Length of grate bars, 7 ft. 6 ins. Number of tubes, above, 168. Internal diameter do., $3\frac{1}{2}$ ins. Length do., 12 ft. Diameter of smoke pipe, 30 ft. Height do., 22 ft. Consumption of fuel per hour, 844 lbs.

PROPELLER.—Diameter of screw, 12 ft. Pitch do., 18 ft. Number of blades, 4.

Date of trial, January, 1861. C. H. H.

New Theory of Cementation. By Mons. H. Caron.

From the London Chemical News, No. 81.

The question which I am about to treat is so complex, that I must request the Academy to allow me to establish clearly the facts on which I found my views before I develop them freely.

In a paper which made some sensation, Mr. Saunderson, an ingenious English manufacturer, concludes,* from his experience, that pure and isolated charcoal, oxide of carbon, ammonia, and bicarburetted hydrogen are unsuited for the manufacture of steel; but he shows that iron can be converted into steel by the simultaneous action of ammonia and olefiant gas. After showing that the well known cementation agents, cyanides and ferrocyanides, act only by their metalloid principle, he says:—"1. The transformation of iron into steel only takes place under the combined influence of carbon and nitrogen. 2. If, in analyses of steel, no mention of nitrogen has hitherto been made, the cause of the omission is that the analyses were either ill-done, or that they were made under the influence of a preconceived idea."

May I be permitted to say that Mr. Saunderson has not done justice to his predecessors, Berzelius, Shaffhaütl, Marchand, &c. As a proof, I transcribe an exceedingly judicious note by M. Nickles, Mr. Saunderson's translator:—

"This assertion is not quite correct. There exists a series of analyses of forge iron, cast iron, and steel, attesting the presence of nitrogen in these metals. It is true they do not all contain it, and the greatest quantity that has been found in them is 0·0002 (*Annuaire de Chimie*, 1851, p. 107). These analyses are so much the more reliable since their author, the late M. Marchand, of Halle, experimented from a point of view entirely foreign to the theory of cementation. After it had been established that the titanium of blast furnaces is not a simple body, but a mixture of cyanide and nitride of titanium, M. Marchand surmised the case might be the same with cast iron and steel. Nothing would have pleased him better than to find nitrogen in these carburets, and no one can say that the negative results were obtained under the influence of a preconceived idea. If, then, steel can be considered as free from nitrogen, it is nothing to the purpose that this gaseous metalloid plays no part in the transformation."

Guided by these trials, which had revealed to me the real part nitrogen plays in cementation, I established, in October, 1860, that one of the most powerful and quickest steeling agents is cyanide of ammonium, a gaseous matter, which, by penetrating to the centre of the iron bars, speedily transforms them into steel of great perfection. And it is remarkable that in every instance of Mr. Saunderson's cementing with hydrocarburetted and ammoniacal gases he unwittingly produced cyanide of ammonium. The same observation applies to M. Fremy's experiment, who also brought into contact ammonia and carburetted hydrogen, successively, it is true, but under such circumstances that

* *Journal de Pharmacie et de Chimie*, 1859, vol. xxxvi, p. 301.

at the moment of reaction the two elements were again found together, and, combining, formed cyanide of ammonium.

It remains for me to prove definitely that whenever iron is converted it is always put into contact with gaseous cyanide of ammonium or with volatile cyanides. This is not a difficult task, since Mr. Saunderson has shown that pure charcoal will not convert, and, according to my own experiments, it is the presence of nitrogen concurrently with the alkali of ashes, and, consequently, the formation of cyanide of potassium, which determines the acieration in the cementation cases.

What, then, is the part these cyanides play? If pure or almost pure charcoal is given to iron,—for example, that of the carburetted hydrogen,—as Mr. Saunderson, M. Fremy, and myself have done, and the operation is conducted at the high temperature generally employed, the metal becomes too quickly saturated with the carbon, and cast iron only is the result. But if the metal be placed in contact with a carburetted matter, the elements of which are combined in an affinity so close that the iron can only overcome it by prolonged contact, the acieration produced on the surface of the bars will not exceed the desirable limit before the centre of the iron is cemented. On reflecting over this matter, it will be seen that the only undecomposable and volatile combinations of carbon are the alkaline cyanides. Then, cyanides only are the cementing agents, at least, with the temperatures used in manufacture. This restriction is important, as will presently be established.

But a too prolonged contact or too high a temperature will soon modify the effects produced. Thus, cyanide of ammonium, instead of cementing, can transform iron into cast iron,—a fact I have several times verified. It is not so easy to produce this result with cyanide of potassium, because it is less volatile and more difficult to decompose, from which it may be concluded that the most effective agent in acieration should be the least volatile cyanide,—that is to say, cyanide of barium,* a compound which I have pointed out in another paper. I shall explain more precisely in regard to this substance in another communication on a new cementation process which has been for some months put in practice in a large manufactory in the environs of Paris, by order and at the expense of the Emperor.

All this will become still more clear if it is made apparent that other substances besides cyanides, containing carbon without nitrogen, can convert iron into steel, provided the temperature is not high enough to decompose them, and that their action is not too prolonged. Pure, light carburetted hydrogen gas passed at red-white heat on iron produces not so speedy, but quite as perfect a cementation as cyanides. It is the same with lighting gas,† which contains a considerable proportion of light carburetted hydrogen gas; and if M. Fremy has been unable to convert iron into steel by means of this agent, it is because he operated at too high a temperature, and protracted too long the con-

* Cyanide of barium is easily produced by simply mixing charcoal dust and natural carbonate of baryta. The nitrogen is furnished either by the charcoal itself or by the air which penetrates the sides of the cementation cases.

† Purified by phosphoric acid and solid potassa.

tact by the reagents. Besides, in Berzelius' first edition (vol. iii, p. 279, 1831), there will be found some details on the fabrication of lighting gas, as shown in England by Macintosh. Nevertheless, I agree perfectly with Mr. Saunderson respecting olefiant gas. I have not succeeded in cementing with this gas, though I have operated at the lowest possible temperature, it being too readily decomposed by heat. The tube in which the operation was conducted was found filled with charcoal, and the iron, in spite of tempering, remained soft and malleable.

Strictly speaking, cyanogen is also capable of cementating, but not so well as light carburetted hydrogen gas. These experiments show that to convert iron into steel it is requisite that the cementation agent should be able to carry the charcoal in combination into the pores of the iron when this metal appropriates it in the nascent state. Under no other conditions can cementation be produced.*

After what I have said, it is useless for me to refer to the existence of nitrogen in steels. My theory is perfectly independent. The quotation from M. Nickles' translation, and the cementations so many, including myself, have effected, without the presence of nitrogen, ought, I think, to decide this point. Let it be remembered also that Marchand, in his careful and delicate analyses, could find only such quantities of nitrogen as were either inappreciable or insignificant; that M. Shaffhaütl, the great partisan of the presence of nitrogen in steels, has been obliged to recognise the exactness of Marchand's observations, the same conclusion will naturally be formed as that of this celebrated German chemist,†—"If there is any nitrogen it must necessarily belong to the substances mingled with the iron,—substances which no more form an integral part of the metal than does the scoria found with it."—*Comptes-Rendus.*

A Charter to Dig for Coal.—Newcastle-upon-Tyne, England.

From the Lond. Engineer, No. 272.

The year 1259 is memorable in the annals of coal mining. Hitherto the mineral had not been recognised by authority or in any public document; but in that year King Henry III. granted a charter to the freemen of Newcastle-upon-Tyne for liberty to dig coals. Under the term "sea-coal" a considerable export trade was established with London, and it speedily became an article of consumption amongst the various manufacturers of the metropolis. But its popularity was short-lived. An impression became general that the smoke arising therefrom contaminated the atmosphere, and was injurious to the public health. Years of experience has proved the fallacy of the imputation; but in

*On this subject I will remark, that it is impossible to suppose that nitride of iron can be formed at any moment during cementation in manufacturing operations. M. Despretz's nitride of iron has never been produced by any other means than by ammonia, which does not exist in cementation cases; and, even if it did, it would be decomposed by the temperature at which the operation is performed. As to nitrogen, it is well known that it does not combine directly with iron. The existence of a nitrate of iron before the formation of steel is, then, inadmissible; but atmospheric nitrogen, in contact with charcoal and potash of the ashes, yields cyanide of potassium, which is the reason why the presence of this agent in the atmosphere of the cases is absolutely necessary.

†*Journal fur practische Chimie*, v. Erdmann und Marchand.

1306 the outcry became so general, that the Lords and Commons in Parliament assembled, presented a petition to King Edward I., who issued a proclamation forbidding the use of the offending fuel, and authorizing the destruction of the furnaces and kilns of all who should persist in using it. This was the year before the monarch's death, and the year which saw the overthrow of his life-long attempts upon the throne of Scotland, through the intrepidity of Robert the Bruce. But the proclamation against coal was as abortive as the endeavor to conquer the patriotism of the Scots. Prejudice gradually gave way as the value of the fossil fuel became better known, and from that time downwards its use became more extended; and it is very probable that throughout the 14th and 15th centuries, coal was extracted near the outcrop of the beds over most, if not all, of the coal-fields of Britain and Ireland. Historical records are still extant, from which we learn that collieries were opened during the 14th century in various parts of Yorkshire, Durham, and Northumberland.—*Hull's Coalfields of Great Britain.*

On the Detection of Bisulphide of Carbon in Coal Gas. By Dr. E. HERZOG.

From the London Chemical News, No. 78.

A solution is prepared by saturating absolute alcohol with ammonia gas. Then a concentrated aqueous solution of acetate of lead is made, and, to insure saturation, a small portion of the solid salt is left in contact. Both these fluids must be preserved in well-stoppered bottles.

The gas to be tested may be conveniently delivered from a length of vulcanized india-rubber tubing, to the end of which is adapted a narrow glass tube, about five or six inches long. Five drops of the sugar of lead solution are then mixed in a test-tube, with about sixty or seventy drops of the alcoholic ammonia. No precipitate will be formed providing the latter solution has not been allowed to absorb any carbonic acid.

The glass tube delivering the supply of coal gas is now immersed in the mixed solution to a depth just sufficient to allow the gas to be forced out by the existing pressure, and to escape in small bubbles. In the event of bisulphide of carbon being present, the liquid becomes gradually colored, and soon afterwards a yellowish-red precipitate is formed, which, by longer action, assumes a brownish color. If carbonic acid existed originally in the gas, then a white precipitate is thrown down, which imparts to the yellow-red a somewhat lighter color.

As a confirmatory experiment, the gas may be first passed through the alcohol ammonia fluid alone, and the lead solution subsequently added, when an orange-colored precipitate, appearing either immediately or very shortly afterwards, will be formed if bisulphide of carbon is present. In order to meet the objection that sulphuretted hydrogen may perhaps have occasioned this reaction, let some of the gas be first passed through a small quantity of the simple lead solution.

The smallest trace of sulphuretted hydrogen causes a blackening of the liquid, whereas bisulphide of carbon does not alter it in the slightest degree.

It should be mentioned that if the yellow-red precipitate be allowed to remain under the fluid, it gradually changes color, and becomes white after the lapse of about twenty-four hours. If, however, the precipitate be filtered immediately, slightly washed, and dried, it becomes a dark brown.

With regard to the explanation of the chemical reactions which occur in this process, the interesting observations made by MM. Zeise and Debus may be quoted as proving that, by the action of sulphide of carbon on ammonia, according to the concentration and temperature of the fluids and the proportion borne by the ammonia to the sulphide, so will the relative amounts of the products of decomposition vary. In concentrated solutions, and when the ammonia is in excess, sulphocarbonate of ammonium and sulphocyanide of ammonium are formed; in dilute fluids and when sulphide of carbon is in excess, xanthonate of ammonia. Therefore, by this experiment one or other product will preponderate according to circumstances, dependent upon the larger or smaller quantity of sulphide of carbon contained in the gas. In any case, compounds of lead are formed corresponding to the ammonia compounds, which possess at first an orange-red and afterwards a golden-yellow color.

Notwithstanding the complicated nature of the chemical reactions involved in the testing of gas by this process, the author recommends its adoption on account of the practical simplicity which, in his hands, attended the working of a great number of comparative experiments. —*Chemischen Centralblatt.*

New Process for Tinning Iron.

From the London Engineer, No. 282.

The chief object we have in view in coating iron with tin is to protect it from oxidation, since victuals cooked in untinned iron vessels, far from acquiring any poisonous quality, as they would in copper, would, on the contrary, become more invigorating in proportion to the iron they might absorb; only their taste would be impaired, and the vessel itself soon become useless. On the other hand, the tin-coating is not very durable, and the process of tinning has, therefore, to be often repeated. To obviate this inconvenience, MM. Vivien and Lefebvre have imagined a process for covering iron vessels with a film of nickel before applying the tin. They accordingly begin by scouring the vessels in a mixture of 320 grammes of sulphuric acid and 7 litres of water; this is done in a wooden cylinder which is made to turn round for about ten minutes; after which the following substances are added to this bath:—60 grammes of white kitchen-salt, 30 grammes of corrosive sublimate, and 2 grammes of pure sulphate of nickel, and the rotary motion is then continued for about an hour longer. At the end of this time, the vessels are found to have received a fine, uninterrupted, and very adherent coating of nickel,

which effectually protects the iron from oxidation. They are then put into cold water, and left there while the following second bath is being prepared, viz:—River water, 50 litres; cream of tartar in powder, 75 decagrammes; tin in plates, 3 kilogrammes. The whole is made to boil for the space of three hours, after which the iron vessels are put in, and the ebullition is continued for two hours more; by which means the vessels receive a coating of tin deposited on the previous one of nickel. They are then dipped into clean water and rubbed with bran and saw-dust to fit them for use.

The Pantelegraph.

From the Lond. Mechanics' Magazine, June, 1861.

M. Caselli has succeeded by means of his pantelegraph in conveying, between Paris and Amiens, portraits of the Emperor Napoleon, the Empress Eugenie, the Prince Imperial, also a plan of the Battle of Moscow, autographs in French, German, Italian, &c. The Morse signals are reproduced perfectly, by means of this invention, at the rate of fifty or sixty words a minute. Two of these pantelegraphs will soon be at work between Paris and Marseilles. M. Caselli proposes to make experiments on a larger scale by establishing pantelegraphs at London, Paris, Marseilles, Florence, and Naples. By means of this single continuous line, and with only four relays, he proposes to convey between Naples and the other stations named, any document or writing of any kind. M. Caselli has already succeeded in establishing, to less than the one-thousandth of a second, the synchronism of two pendulums, one oscillating at Paris, the other at Marseilles, and these synchronisms are independent of the variations in the current of the electric telegraph which joins the two pendulums.

Decimal Coinage in Denmark.

From the Lond. Mechanics' Mag., June, 1861.

In the kingdom of Denmark a decimal system of coinage has just been adopted. It comprises four denominations of silver, and one of bronze coins. These are named respectively twenty, ten, five, three, and one cent pieces. The largest coin of the series, which corresponds closely in value with the franc of the French Empire, has for its obverse the well-engraved and massive-looking head of the king in profile, and surrounded by the legend "Frederick III., Konge Af Danmark," with the date. The reverse represents a ship in full sail over a rippled sea, and bears the inscription, which we leave Danish scholars to translate—"Dansk Vestindisk Mout," with the value of the coin "20 cents," underneath. The ship, no doubt, is emblematical of the commerce of the country, and the superiority of its inhabitants as navigators. The next coin in point of value, although decorated with the head of the monarch for its obverse, and having the same legends, has a reverse design of quite a different character; namely, a tall shrub or plant, in flower, which is, of course, indige-

nous to Denmark. It presents a rather singular appearance. As, however, agriculture is largely pursued by the people, it is not an inappropriate device. The five cent piece is a reduced fac-simile of the first named, whilst on the three cent coin neither ship nor shrub appears, but in their place a conspicuous figure 3 is seen, with the word cents below it. The one cent bronze bears no family likeness to its silver relatives. In place of the royal head, it has for its obverse the royal arms, which consists of three lions, each surmounted by three hearts, on a shield, and with a crown placed above the whole, the inscription being "Frederick VII., Konge Af Danmark." The reverse exhibits simply a wreath of oak leaves, encircling the value of the coin, "1 cent," and has the inscription "Dansk Vestindisk," immediately within the ingrained edge. The coins are all well proportioned as regards thickness and diameter, and well engraved; and while the edges of the silver pieces are milled or grained, in a manner resembling our own gold and silver moneys, those of the bronze coins are plain.

We cannot but congratulate our Danish friends on having obtained a system of decimal coinage which, while it will facilitate marvellously the transactions of trade, will economize to no inconsiderable extent the time of the schoolmaster and the book-keeper. When will Great Britain follow suit?

AMERICAN PATENTS.

AMERICAN PATENTS ISSUED FROM JUNE 1, TO JUNE 30, 1861.

Air Chambers,	Robert Creuzbaur,	Travis co.,	Texas,	18
Apple Parer,	S. S. Hersey,	Farmington,	Me.	18
Arastra,	Woodworth & Wethered,	Murphys,	Cal.	11
Axle Collars,	E. S. Scripture,	City of	N. Y.	4
Bedstead Drapery Fastener,	R. B. Pullan,	Cincinnati,	Ohio,	18
——,—Trunk convertible to	W. B. Strong,	City of	N. Y.	11
Beehives,	R. Bullard,	Litchfield,	Mich.	4
——	Oliver Reynolds,	Webster,	N. Y.	4
Bell-ringing Apparatus,	Rhodolphus Kinsley,	Springfield,	Mass.	11
Bit Stock,	John F. Cory,	City of	N. Y.	25
Boiling Apparatus,	John McCormick,	Madison,	Ind.	25
Bolts,—Heading	James Weathers,	Greensburg,	"	11
Boot Heels,	George A. Mitchell,	Turner,	Me.	25
—— Jack,	W. H. Towers,	City of	N. Y.	4
Boots and Shoes,	J. C. Plumer,	Portland,	Me.	4
——	Christopher Meyer,	N. Brunswick,	N. J.	18
Boot & Shoe Soles,—Skiving	Wm. F. Trowbridge,	Feltonville,	Mass.	25
Boring and Mortising,	S. W. Bidwell,	Hartford,	Conn.	11
—— Machine,	S. L. Fitts,	Ashburnham,	Mass.	11
Bottles,—Inserting Stoppers in	Amasa Stone,	Philadelphia,	Penna.	18
Bottle Stoppers,	J. A. Preston,	Boston,	Mass.	25
Brakes,—Car	G. W. Bridgman,	Somerville,	"	11
——	W. R. and H. E. Kay,	Westerly,	R. I.	25
—— for Vehicles,	J. A. Whitney,	Maryland,	N. Y.	25
Bridges,—Braces of Iron	A. D. Briggs,	Springfield,	Mass.	18
——,—Trusses of	J. H. Junkins,	U. Sandusky,	Ohio,	4
Brush,—Flexible Back	J. J. Adams,	City of	N. Y.	18

Brush,—Galvanic Metal Friction	L. A. Hoffman,	Prussia,		25
Buggy Tops,	L. H. Gano,	Ripon,	Wis.	18
———— ———,—Frames of	J. H. Havens,	Troy,	Ohio,	4
Burglar Alarm & Animal Trap,	George Smith,	City of	N. Y.	11
Canal Boats,—Stanchion for	C. Van Name,	Binghampton,	N. Y.	11
Carpet Cleaner,	George & Carter,	Nashua,	N. H.	4
Car Spring,	G. L. Turner,	City of	N. Y.	18
Carriage Bodies,	W. C. and J. Dunn,	"	"	11
——— Steps,	H. T. Betts,	Springfield,	Mass.	4
Chair,—Adjustable	Amos Chase,	North Weare,	N. H.	11
Chairs,—Cane Seat for	J. B. Sawyer,	Templeton,	Mass.	11
Camp Chest,	George Parr,	Buffalo,	N. Y.	25
Churn,	C. T. Anderson,	Hyattstown,	Md.	18
Cloth,—Making Felt	G. G. Bishop,	Norwalk,	Conn.	25
Clothes Frame,	M. J. Knox,	Knox Corners,	N. Y.	18
——— Wringer,	G. B. Griffin,	Madison,	Wis.	4
———— .	W. B. Rhoades,	South Dedham,	Mass.	25
Clover Seed,—Hull'g & Clean'g	F. E. Cook,	Guilford,	Ohio,	4
————	Jacob Kuhn,	Centerville,	Penna.	25
Coolers and Condensers,	Wm. A. Lightall,	City of	N. Y.	11
Coupling,—Belt	Samuel Metzler,	Naperville,	Ill.	25
———,—Car	Abraham Stroh,	Port Jervis,	N. Y.	11
———— .	A. H. Trego,	Lambertville,	N. J.	11
Cork Machines,	Isaac Goodspeed,	Norwich,	Conn.	4
Corn Broom,	C. L. W. Baker,	Hartford,	"	11
Cotton Seed,—Detach. Fibres	L. P. Jenks,	Boston,	Mass.	25
Crane,—Portable	L. A. Beardsley,	S. Edmeston,	N. Y.	25
Cranks,—Overcom. Dead Point	John Griffin,	Louisville,	Ky.	11
Cultivators,	Cain & Stelfox,	Austin,	Texas,	4
————	R. F. Joynes,	Bristol,	R. I.	4
————	John Keezer,	Chillicothe,	Ohio,	18
————	Joseph & St. Clair Gum,	Marseilles,	Ill.	18
Curry Combs,	H. L. Baldwin,	Branford,	Conn.	11
Cut Nails,—Annealing	James McCarty,	Reading,	Penna.	11
Daguerreotype Cases,	Ralph Hill,	City of	N. Y.	18
Dish Covers,—Wire Cloth	L. H. Allen,	Amherst,	Mass.	4
Drawing Instrument,	John P. Jamison,	City of	N. Y.	18
Electro-magnet,	A. G. Holcomb,	City of	N. Y.	4
Evaporating Liquids,—Apparat.	John Trageser,	"	"	11
Excavating Machine,	W. F. Wickersham,	St. Louis,	Mo.	25
Excavators,	Jesse Bartoo,	East Aurora,	N. Y.	4
Fire Arms,—Breech-loading	Herman Schroder,	City of	N. Y.	25
Fruit-drying Apparatus,	Eli Duncan,	West Hilton,	Ohio,	18
Furnaces of Locoms.—Blowers	F. B. Blanchard,	City of	N. Y.	25
Gauge,—Pressure	Finnegan & Schulte,	City of	N. Y.	11
Galvanic Soles,	Samuel Nowlan,	"	"	18
Games of Chance,—Select. Balls	Mortimer Nelson,	"	"	18
Gas by Electricity,—Lighting	Robert Cornelius,	Philadelphia,	Penna.	4
—— Regulators,	G. H. Smith,	Rochester,	N. Y.	25
Grain Drills,	H. A. and L. B. Myers,	Elmore,	Ohio,	25
—— Winnowers,	H. H. Beach,	Philadelphia,	Penna.	11
Griddles,—Moulding Stove	M. C. Burleigh,	Somersworth,	N. H.	4
Harrows,	Moses Bucklin,	Grafton,	N. H.	4
————	J. T. Foster,	Jersey City,	N. J.	18
————	T. C. Hooker,	Kendall,	N. Y.	18
————,—Seeding	Edward Badlam,	Ogdensburgh,	"	18
Harvesters,	Robert Brown,	Frederick,	Md.	18
————	G. W. Richardson,	Grayville,	Ill.	25

Harvesters,—Rakes for	W. S. Wilmot,	City of	N. Y.	4
Harvesting Machines,	Franklin Clark,	Charlotte,	"	18
Hat Bodies,—Felting	Russell Smith,	Danbury,	Conn.	4
Hats.—Circ. Looms for Weav'g	Louis Bonard,	City of	N. Y.	4
Heating Apparatus,	Porter Mitchell,	Greenfield,	Mass.	25
———————,—Steam	Wm. C. Baker,	City of	N. Y.	4
Hemming Guides	G. L. Jencks,	Providence,	R. I.	11
Hemp Brakes,	J. H. Phillips,	Waverly,	Mo.	11
Hinges,	C. M. Lane,	Cincinnati,	Ohio,	4
Hominy Machines,	David Haines,	Union Bridge,	Md.	11
Horse-hitching Posts,	Chas. Bush,	Newburgh,	N. Y.	18
Horse Shoes,—Making	C. H. Perkins,	Providence,	R. I.	25
Hydraulic Jack,	R. Blackwood,	Philadelphia,	Penna.	25
Inkstands,—Barometer	T. S. Hudson,	E. Cambridge,	Mass.	4
Iron and Steel,—Malleable Cast	A. K. Eaton,	City of	N. Y.	25
Journal Box,	Joel Webster,	Brooklyn,	N. Y.	18
Lamps,	E. F. Slocum,	Chicago,	Ill.	11
Lard.—Refining	H. S. Lewis,	"	"	25
Leather,—Dressing	Charles Korn,	Meriden,	"	25
———,—Tanning	H. McKenzie,	Talladega,	Ala.	11
——— for Soling,—Preparing	Davoust Kern,	York,	Penna.	25
Lock.	John Adt,	Waterbury,	Conn.	25
Locks and Knob Latches,	A. M. Hill,	Branford,	Conn.	11
———————	W. S. Kirkham,	"	"	11
Looms,	Caspar Zwicki,	Pittsburgh,	Penna.	4
———,—Picker Motion for	John Robinson,	Andover,	Mass.	18
——— for Weaving Hair Cloth,	Isaac Linsley,	Providence,	R. I.	25
Lubricating Compound,	A. Lebkucher,	Belleville,	Ill.	25
Medical Powder Papers,—Filling	Mark S. Palmer,	New Bedford,	Mass.	25
Melodeons,	Wm. F. Sheldon,	East Mendon,	N. Y.	25
Mercury in Vessels,—Condens.	Van Buren Ryerson,	City of	"	4
Mills,—Grinding	S. S. Howard,	Milton,	"	18
———————	Krause & Strong,	Chicago,	Ill.	18
Millstones,—Leveling	Andrew Dray,	Portland,	Oregon,	18
———,—Feeding Grain to	S. G. Morrison,	Williamsport,	Penna.	18
———,—Ventilating	"	"	"	18
Nail Heads,	Nichols & Strong,	E. Hampton,	Conn.	11
—— Machine,—Horse-shoe,	S. S. Putnam,	Dorchester,	Mass.	11
Oils.—Distilling	Kelley & Tait,	City of	N. Y.	18
Ox Yokes,	T. W. Porter,	Bangor,	Me.	25
Padlock,	J. J. Hirschbuhl,	Louisville,	Ky.	18
Paint,—Article of	Isaac Tyson, Jr.,	Baltimore,	Md.	4
Paving and Pulverizing the Soil,	R. J. Gatling,	Indianapolis,	Ind.	18
Photography,	J. W. Osborne,	Melbourne,	Engl'd,	25
Pipe Butts,	L. S. Bunnell,	Troy,	N. Y.	4
Pistols,—Toy	Cutler & Jenkins,	City of	"	25
Ploughs,	Zadoc M. Beall,	Russellville,	Ky.	4
———	Wm. Lape,	Troy,	N. Y.	25
———	L. M. Stearns,	Cardiff,	"	4
———,—Hillside	Augustus Sanborn,	Glover,	Vt.	18
———,—Steam	C. W. Saladee,	Pine Island,	Texas,	25
Preserve Jars,	J. M. Whitall,	Philadelphia,	Penna.	18
Propeller,—Screw	David Bell,	Buffalo,	N. Y.	25
Pumps,	Nathan Barrett,	City of	"	25
———	Nathan Miller,	Finley,	Ohio,	18
———	W. W. Robinson,	Ripon,	Wis.	4
———	V. Weitz,	Cleveland,	Ohio,	18

Railroads,—City	E. F. Hyde,	Brooklyn,	N. Y.	11
Railroad Switch,	O. W. Marshall,	Windsor Locks,	Conn.	18
Railways,—City	P. Andrew,	Cincinnati,	Ohio,	25
Ratan Machine,	N. H. Richardson,	Fitchburg,	Mass.	25
Rope,—Opening	Richard Mansley,	Philadelphia,	Penna.	11
—— Walks,	Horace Maxson,	Hopkinton,	R. I.	4
Rulers,	George Lane,	City of	N. Y.	18
Sash-holders,	H. T. Stanard,	Wayne,	Mich.	25
Saw Teeth,—Cutting	J. D. Custer,	Norristown,	Penna.	25
Saws to Arbors,—Circular	John Andrews,	Brunswick,	Me.	11
Sawing Machines,—Scroll	L. D. Barrand,	City of	N. Y.	11
Seed Drills,	John and Saml. Fahrney,	Washington co.	Md.	18
Seeding Machines,	Grout & Lawton,	Oak Grove,	Wis.	4
————	Gilbert Jessup,	Chapinville,	N. Y.	25
Sewing Machines,	Wm. M. Fuller,	Chicago,	Ill.	4
————	Edward Howell,	Ashtabula,	Ohio,	11
————,—Threader &c.	J. W. Hardie,	City of	N. Y.	25
Shingle Machines,	A. H. Clark,	Fond du Lac,	Wis.	4
————,—Tilt. Device	D. M. Boyd,	Indianapolis,	Ind.	25
Ships,—Life or Safety	Mathew Gill,	Battle Creek,	Mich.	25
Shoulder Straps,—Officers'	J. S. Smith,	City of	N. Y.	18
Sirups,—Decolorizing	H. N. Fryatt,	Belleville,	N. J.	25
Skates,	J. A. De Brame,	City of	N. Y.	4
——	D. H. Shirley,	Boston,	Mass.	25
Skirts,—Hoop	S. R. Wilmot,	Brooklyn,	N. Y.	11
Skirt Supporters,	Sarah A Baldwin,	Waterbury,	Conn.	11
Soda,—Caustic	Henry Lowe,	Baltimore,	Md.	11
Spike Machine,	Samuel Cameron,	Pittsburgh,	Penna.	4
Spoke Shave,	Martin Colton,	Sardinia,	N. Y.	25
Spools,—Turning	J. S. Parker,	W. Willington,	Conn.	11
Steam Boiler,	F. B. Blanchard,	Brooklyn,	N. Y.	25
—— Boilers,—Apparatus for	G. W. Rains,	Newburgh,	"	11
————,—Damper for	J. R. Robinson,	Boston,	Mass.	11
————,—Safety Guard	George Mann, Jr.,	Ottawa,	Ill.	18
————,—Tubular Grates	S. C Sturtevant,	Cleveland,	Ohio,	11
—— Engines,	E. W. Smith,	City of	N. Y.	11
————,—Governors for	C. T. Porter,	"	"	18
————,—Rotary Valve	Jerome Wheelock,	Worcester,	Mass.	18
————,—Slide Valve	A. J. Stevens,	Aurora,	Ill.	18
————,—Valve Gear	J. R. Robinson,	Boston,	Mass.	11
—— Heating Apparatus,	Charles Gregg,	City of	N. Y.	18
Steel,—Converting Iron into	E. R. Weston,	East Corinth,	Me.	11
Stills,—Securing Bottoms to	J. G. Collins,	Boston,	Mass.	18
Stoves,—Fire Pot for Coal	Dennis G. Littlefield,	Albany,	N. Y.	25
Teasels,—Trimming	George M. Rhoades,	Hamilton,	N. Y.	25
Telegraphic Apparatus,	C. H. Burd,	Roxbury,	Mass.	11
Tent Fixtures,	J. H. Landell,	Newark,	N. J.	4
Thrashing and Separating Grain,	Hiram Aldridge,	Michigan City,	Ind.	11
—— Machines,	W. P. Penn,	Belleville,	Ill.	18
Tobacco,—Curing	B. C. Bibb and others,	Baltimore,	Md.	25
—— Cutters,	H. U. and H. A. Morse,	Canton,	Mass.	25
Traps,—Animal	Decatur Pittman,	Fort Madison,	Iowa,	4
Trap,—Steam	Wiggin & Hoard,	Providence,	R. I.	4
Trimmings,—Making Tape	J E Earle,	Brooklyn,	N. Y.	25
Tube and Pail Machine,	Peck & Gifford,	Wolcott,	Vt.	25
Valves,	Leopold Thomas,	Allegheny,	Penna.	25
Ventilating Hay, Grain, &c.,	Abel Post,	Henrietta,	N. Y.	18
Wall Paper, &c.,—Bronzing	W. G. Mackay,	City of	N. Y.	25
Washing Machines,	Horace Boies,	Hamburgh,	"	25

Washing Machines,	H. M. Collier,	Binghampton,	N. Y.	4
———	D. R. Gamble,	Newark,	Ohio,	25
———	E. Gore,	Belvidere,	Ill.	4
Water Elevators,	A. W. Dewey,	Boston,	Mass.	25
———	Joel Lee,	Galesburg,	Ill.	25
———	F. B. McGregor,	Commerce,	Mich.	18
———	Eli Mosher,	Flint,	"	18
———	George Race,	Norwich,	N. Y.	25
———	M. A. Shepard,	Bridgeport,	Ill.	25
——— for Cattle	Nathan Miller,	Finley,	Ohio,	18
———	M. D. Wilder,	Laporte,	Ind.	25
Window Blinds,	D. deForest Douglas,	Springfield,	Mass.	11
——— Sash,—Hanging	George Dare,	Auburn,	N. Y.	4
——— Shades,—Manufact. of	F. A. Perry,	St. Louis,	Mo.	11

RE-ISSUES.

Car Spring,	Richard Vose,	City of	N. Y.	4
Fire Arms,—Breech-loading	Christian Sharps,	Philadelphia,	Penna.	18
Grain Separators (2 patents),	J. A. Vaughn,	Cuyahoga F'ls,	Ohio,	11
Harvesters,	Wm. N. Whiteley, Jr.,	Springfield,	"	25
Hemp,—Cutting (3 patents),	"	"	"	18
Locks,—Door	G. D. Baldwin,	City of	N. Y.	4
Seeding Machines,	Lewis Moore,	Ypsilante,	Mich.	18
Shirt Bosoms,	Ira Perego, Jr.,	City of	N. Y.	11

DESIGNS.

Coffins,	James McDuff,	Morrisania,	N. Y.	25
Daguerreotype Cases,—Mat for	H. W. Hayden,	Waterbury,	Conn.	25
Oil-cloth Pattern,	James Hutchinson,	Lansingburgh,	N. Y.	25
Trade Mark,	Levi L. Tower,	Boston,	Mass.	11
Tumblers,	C. S. Chaffee,	E. Cambridge,	"	25

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, August 15, 1861.

John C. Cresson, President, in the chair.

John Agnew, Vice President,
Isaac B. Garrigues, Recording Secretary, } Present.

The minutes of the last meeting were read and approved.

Letters were read from Thomas Oldham, Esq., Superintendent of the Geological Survey of India, and of the Geological Museum, Calcutta, India; and from Messrs. Eives & Macey, London, England.

Donations to the Library were presented by the Statistical Society, and the Institute of Actuaries, London; the Royal Irish Academy, Dublin, Ireland; the Society for the Encouragement of Industry in Prussia, Berlin, Prussia; the Governor-General of India, Calcutta, India; the Regents of the University of New York, Albany, New York; and from Jacob S. Miller, Esq., Philip Price, Esq., George M. Conarroe, Esq., and Prof. John C. Cresson, Philadelphia.

The Periodicals received in exchange for the Journal of the Institute, were laid on the table.

The Treasurer's statement of the receipts and payments for the month of July was read.

The Board of Managers and Standing Committees reported their minutes.

Candidates for membership in the Institute (2) were proposed, and the candidates proposed at the last meeting (2) were duly elected.

Mr. Howson called the attention of those present to a new form of Scale-beam, the invention of Mr. A. B. Davis of this city. The improvement consists in the use of a supplementary beam suspended by a clevis beneath the beam as usually constructed, and the article to be weighed being suspended from a clevis attached to the lower beam.

The upper beam is graduated in the usual manner, and is furnished on each side with three knife edge bearings of the usual form, the beam being supported by a stationary clevis, in which the centre bearings rest.

The second graduated beam is situated immediately below the first, and is provided at each end with knife edge bearings situated directly beneath those on each end of the upper beam; the two beams being connected by a clevis suspended on the bearings.

Between the two knife edge bearings on the lower beam is situated another, from which depends a clevis for receiving the object to be weighed. While the bearings at the ends of the beams are an equal distance apart on each beam, the distance between the end bearing and the bearing supported by the stationary clevis on the upper beam, is greater than the distance between the end bearing and that holding the weighing clevis on the lower beam; the two beams being graduated into spaces equal to the difference of the distances of the central bearings from the end ones, so that a weight of 20 lbs. suspended to the central clevis of the lower beam would exactly balance a weight of 1 lb. placed at a notch twenty spaces from the fulcrum on the upper beam.

It would be impossible to suspend the clevis holding the object to be weighed directly to the upper beam so near its fulcrum, as it would interfere with the proper movements and functions of the beam; hence the employment of the supplementary beam, which obviates the necessity of using the usual long beam, and produces a more compact and manageable weighing apparatus.

This will be more apparent when it is borne in mind that the distance between the two centre bearings may be, if necessary, but one-tenth of an inch, in which case a weight of 1 lb. hung to the upper beam at the distance of ten inches from its fulcrum, would balance a weight of 100 lbs. suspended from the centre bearing of the lower beam.

One of the main advantages gained by this improvement is, that the two beams afford an opportunity of weighing the tare on one beam and the actual merchandize on the other. If a cart-load of coals be on the platform of the scale with which the beams are connected, the weight on one beam is adjusted to a point which will balance the weight of the horse and cart, so that when the sliding weight on the lower beam is adjusted to a point which will balance the horse and cart, together with the contents of the latter, the actual weight of the contents may be at once ascertained without any calculation.

METEOROLOGY.

For the Journal of the Franklin Institute.

The Meteorology of Philadelphia. By JAMES A. KIRKPATRICK, A.M.

JULY.—The mean temperature of July was 76·1°, which is nearly one degree lower than that of July, 1860, and two degrees below the average temperature of July for eleven years.

The warmest day of the month was the 8th, of which the mean temperature was 87·8°. The highest point indicated by the thermometer was 95° on the same day.

The coldest day was the 14th, of which the mean temperature was 64·2°. The 2d day of the month was but eight-tenths of a degree warmer. The thermometer indicated the lowest temperature (55°) on the morning of the 3d. The range of temperature for the month was 40°.

The greatest daily oscillation or change of temperature in the course of one day, was 26° on the 3d. The least daily oscillation was 9° on the 14th. The average oscillation for the month (19·29°) was but one-tenth of a degree greater than the average for July for eleven years, and half a degree less than for July, 1860.

The greatest daily range of temperature—that is, the greatest mean difference of temperature between two successive days—was 9·3° between the 2d and 3d; the least was eight-tenths of a degree between the 23d and 24th. The average daily range for the month was 3·7°, which was very near the average for eleven years, but was more than one degree less than that for July, 1860.

The atmospheric pressure was greatest (29·961 inches) on the 5th, and least (29·505 inches) on the 20th; but the mean daily pressure was least (29·552) on the 10th of the month. The average pressure for the month (29·781) was less than for any other month of July since 1851, when it was but 29·743 inches.

The greatest mean daily range of pressure for the month was 0·197 of an inch, and occurred between the 20th and 21st; the least was 0·010 of an inch between the 4th and 5th; and the average for the whole month was 0·078 of an inch, which is five-thousandths of an inch less than usual, and more than three-tenths of an inch less than for July of last year.

The force of vapor and dew point were greatest on the 29th and least on the 2d of the month, and both were less than the average for eleven years. The relative humidity was greatest on the 14th, and least on the 3d and 4th of the month. It was a little over one per cent. less than the general average for the month, though greater than usual at 9 P. M.

Rain fell on 14 days of the month, to the aggregate depth of 2·826 inches. This was two inches more than fell in July of last year, but was nearly one inch less than the average amount for the month. The number of rainy days was greater than usual, though but a small quantity of rain fell on each occasion.

Thunder showers occurred on seven days of the month, viz: on the 9th, 10th, 19th, 20th, 27th, 28th, and 31st. During that of the 9th, a house in Walnut street above Fifth was struck by lightning. The fluid knocked down a chimney, tore off a portion of the roof, and then de-